AFIT/GEEM/EN/95D-07

# A CASE STUDY OF THE ENVIRONMENTAL IMPACTS OF THE BEDDOWN OF THE C-17 GLOBEMASTER III AT CHARLESTON AFB

THESIS

Richard H. Houghton Jr., Captain, USAF

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THESIS

Presented to the Faculty of the School of Engineering

Air Education and Training Command

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in

Engineering and Environmental Management

Richard H. Houghton Jr., B.E.

Captain, USAF

December, 1995

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Richard H. Houghton Jr.

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## *List of Acronyms*

| | |
|---|---|
| AICUZ | Air Installation Compatible Use Zone |
| AFAM | Air Force Acquisition Model |
| AFI | Air Force Instruction |
| AFMC | Air Force Material Command |
| AFSC | Air Force Systems Command |
| AMC | Air Mobility Command |
| ASC | Aeronautical Systems Center |
| ASD | Aeronautical Systems Division |
| CAFB | Charleston Air Force Base |
| CATEX | Categorical Exclusion |
| CEQ | Council on Environmental Quality |
| CFR | Code of Federal Regulations |
| DoD | Department of Defense |
| DoDI | Department of Defense Instruction |
| DoDIG | Department of Defense Inspector General |
| EA | Environmental Assessment |
| ECAMP | Environmental Compliance Assessment and Management Program |
| EIAP | Environmental Impact Analysis Process |
| EWG | Environmental Working Group |
| FSD | Full Scale Development |

| | |
|---|---|
| HC | Hydrocarbons |
| IPS | Integrated Program Summary |
| LSAR | Logistic Support Analysis Record |
| MAC | Military Airlift Command |
| MD | McDonnell Douglas |
| MDAP | Major Defense Acquisition Program |
| NEPA | National Environmental Policy Act |
| NOV | Notice of Violation |
| ODC | Ozone Depleting Chemicals |
| OTA | Office of Technology Assessment (U.S. Congress) |
| P2 | Pollution Prevention |
| PMD | Program Management Directive |
| PPA | Pollution Prevention Act |
| PEA | Programmatic Environmental Assessment |
| RM&AE | Reliability, Maintainability and Availability Evaluation |
| SCDHEC | South Carolina Department of Health and Environmental Control |
| USAF | United States Air Force |
| USEPA | United States Environmental Protection Agency |

## *Abstract*

United States Air Force acquisition environmental planning has changed significantly since the passage of the National Environmental Policy Act in 1969. This research examined the role of environmental planning in weapon system acquisition. It focused on environmental planning performed for the C-17 Globemaster III prior to its beddown at Charleston Air Force Base. The case study of the C-17 beddown included interviews, archival record reviews, and direct observations at the base. Evidence was collected to determine what environmental impacts occurred during the beddown. An environmental postaudit compared actual impacts with those predicted in environmental planning documentation. Impacts were analyzed to determine if they resulted from local conditions or requirements. A framework of the acquisition process was constructed and environmental requirements were flowcharted. A timeline of C-17 events was developed for comparison of C-17 history with an ideal acquisition process. Finally, environmental planning documentation was evaluated using 20 objective criteria to determine its quality. Two minor impacts were identified at Charleston AFB during data collection in June 1995 - two years after the first C-17 arrived there. Impacts did not result from unique local conditions. Recommendations were presented regarding the quality and timing of weapon system environmental planning.

# A CASE STUDY OF THE ENVIRONMENTAL IMPACTS OF THE BEDDOWN OF THE C-17 GLOBEMASTER III AT CHARLESTON AFB

## I. Introduction

### Chapter Overview

This chapter describes the problem addressed by this thesis, outlines the scope of research, and summarizes the methodology used to explore the role of environmental planning in weapon system acquisition.

### Purpose of the Study

This study explores the role of environmental planning in weapon system acquisition. It describes historic and current environmental planning guidance used by the United States Air Force (USAF) in the acquisition process. Within this framework, a case study is used to analyze the environmental planning conducted in the acquisition of the C-17 Globemaster III aircraft. Actual environmental impacts caused by the C-17 beddown at Charleston Air Force Base (CAFB) are compared to those predicted in environmental analysis documentation. Results of the study provide feedback to the acquisition community regarding lessons learned from past weapon system environmental planning.

### Background

The National Environmental Policy Act (NEPA) of 1970 mandates environmental planning for all major federal actions such as the acquisition of a new weapon system (Lillie and Lindenhofen, 1991:31). Since the NEPA was passed, dozens of laws and environmental regulations, encompassing thousands of pages, have been published. The

Department of Defense (DoD) responded to these regulations with an array of environmental programs. In the Air Force, these programs are most often managed at installation environmental management offices. Much of the effort in these offices is focused on complying with today's regulations while cleaning up yesterday's contaminated sites. Key planning for tomorrow's environmental changes occurs in the acquisition community, where new weapon systems are designed and developed. Decisions made during acquisition can have long term environmental impacts because the acquisition process represents an early phase in the life cycle of Air Force weapon systems. Quality environmental planning during weapon system development can result in reduced environmental impact at later stages in the life cycle.

One way to gain insight into the quality of Air Force environmental planning is to analyze NEPA documentation for a major federal action. This can be done using an environmental postaudit. A postaudit is a tool that analyzes NEPA planning by comparing actual and predicted impacts of projects subjected to environmental analysis required by the NEPA. Environmental professionals, including the President's Council on Environmental Quality (CEQ), are calling for increased use of environmental postaudits (Culhane, 1993: 66). This thesis features a postaudit of the environmental analysis for the acquisition and beddown of the recently fielded C-17 cargo aircraft.

The McDonnell-Douglas C-17 Globemaster III is a weapon system that the U.S. Air Force developed in the 1980s and fielded in the 1990s. The first squadron of C-17s is currently being bedded down at Charleston AFB, South Carolina. The initial Globemaster III deployed to Charleston in 1993. C-17s will continue to be added to the Charleston fleet through 1998. Much of the environmental planning for the aircraft beddown occurred in 1989, when the environmental assessment was published by Headquarters Military Airlift Command (Department of the Air Force, 1989: 1). This document was reviewed as part of this research.

## Justification for the Research

Environmental postaudits are rare (Culhane, 1993: 67). They contribute to the state of the art of environmental analysis by providing feedback from previous experience. The postaudit performed as part of this research is a contribution to the growing database of environmental information which is a valuable tool for acquisition environmental planners. Further, as recently as December, 1993, the DoD found that environmental issues are not efficiently considered in the acquisition process (Noble, 1994:30). This case study provides information that illuminates environmental issues in the acquisition process.

## Problem Statement

Installations have site-specific environmental requirements that must be identified and addressed early in weapon system development. Study of the beddown of a recently deployed weapon system can yield insight into the success of our acquisition environmental planning and the extent to which local environmental requirements should be considered in the acquisition process.

## Research Objective

The objective of this research was to use the C-17 beddown as a case study to determine the effectiveness of environmental planning in weapon system acquisition, and to suggest procedures to improve environmental planning in the development and beddown of future weapon systems. DoD leaders need criteria for measuring success in environmental programs. Such criteria are defined by various sources in the literature, and can be used to judge the quality of major defense acquisition environmental programs. While many models exist to assess actual impacts and outcomes of major federal decisions, "these models have been adopted only sporadically by U.S. federal agencies" (Culhane, 1993: 66). This research focuses on one major federal action that included

NEPA planning. It compares actual and predicted environmental impacts. Results of the comparison provide valuable lessons that can be applied to future environmental planning activities.

This thesis explores the relationship between environmental planning and the acquisition process in detail. The concept of pollution prevention is described, with particular attention to its role in the acquisition process. The analysis of the C-17 beddown determines how much environmental planning was incorporated in aircraft acquisition, and to what extent environmental analysis predictions matched the actual experience at the beddown location. Measures of merit are developed and employed to characterize the acquisition environmental planning for this weapon system. Special attention is paid to the question of whether local environmental concerns at the beddown location require additional planning early in the acquisition process.

**Research Questions**

Four research questions were developed as part of this research. These four questions guided research efforts and provide the focus for analysis of information collected. The research questions are listed below:

1. What environmental problems occurred during the beddown of the C-17 at Charleston Air Force Base (CAFB)?

2. Which, if any, CAFB environmental problems resulted from unique local environmental requirements or conditions?

3. How were CAFB environmental issues addressed during the C-17 acquisition process?

4. What lessons learned from the C-17 beddown at CAFB can be applied to other weapon system beddowns?

## Scope and Limitations

This research focused on one weapon system, bedded down at one operational base. Although the lessons learned are instructive, they represent a small sample from the universe of Air Force weapon systems. Another possible limitation is that field observations at Charleston AFB were made before the researcher collected information at the Wright-Patterson AFB acquisition offices. This approach has benefits as well as drawbacks. One benefit is that the field observations were made objectively, with only the research questions as a guideline. One drawback is that without the acquisition framework, some data was not identified for collection until late in the analysis process. A further limitation was that portions of the environmental assessment documents for Charleston AFB remain classified. Despite the existence of classified material, enough material is unclassified to make the analysis feasible. Overall, the information presented in this thesis contributes to the advancement of knowledge in the field of acquisition environmental analysis, while leaving a large amount of follow-on work available for future research.

## Research Approach

A case study was designed and performed. The study was structured to collect environmental information about CAFB and analyze it with regard to the relationship between acquisition and environmental planning. Information was collected across environmental media and from multiple installation organizations. Four research questions were answered through a case study structure that included interviews with base personnel, document reviews and site observations.

The methodology used to answer the research questions included the following:

a. Evidence collection,

b. Construction of a framework for environmental planning in acquisition, and

c. An environmental postaudit of C-17 planning documentation.

This three-step process allowed the researcher to observe the impacts of the C-17 at Charleston Air Force Base, then to evaluate the planning process and compare environmental impacts with those predicted by the CAFB environmental assessment.

## Outline

Chapter 2, Literature Review, presents and summarizes the literature in the areas of acquisition and environmental planning. It presents background information about the acquisition process and the C-17 in particular. It highlights the need for better environmental planning in weapon system acquisition.

Chapter 3, Methodology, details the research approach and the methods used to collect and analyze evidence in order to answer the research questions.

Chapter 4, Analysis, presents the results of the research.

Chapter 5, Summary, presents conclusions reached from the analysis and lessons learned for future weapon system development.

## Summary

This chapter presented a research problem and outlined the approach used to explore the role of environmental planning in weapon system acquisition. Case study procedures were presented. The beddown of the C-17 Globemaster III at Charleston AFB was introduced as the subject of the case study.

# II. Literature Review

## Chapter Overview

This chapter provides background information about the salient issues related to this research. It highlights development of both the environmental planning arena and the acquisition process. Relevant environmental legislation is briefly summarized. Key requirements of the National Environmental Policy Act (NEPA) are presented as they relate to weapon system acquisition. The role of pollution prevention in environmental planning is then discussed in detail. Attention is then directed to the DoD weapon system acquisition process, and the exercise of this process in the procurement of the C-17. Finally, the relationship between environmental planning and acquisition is discussed and illustrated in the case of the C-17.

## The National Environmental Policy Act

In late December 1969, Congress passed the National Environmental Policy Act (NEPA). This act, signed as Public Law 91-190 by President Nixon on January 1, 1970, ushered in the "...decade of environmental concern" (Jain, 1993: 43). The purposes of the NEPA were stated in the first paragraph of the law. They were to encourage harmony between man and his environment, prevent damage to the environment, enrich understanding of ecological processes and establish a council of environmental quality.

As applied to Federal actions, the act represents a requirement to consider environmental consequences before making a major decision. "NEPA has become an

'action-forcing' mechanism, insuring that Federal decision-makers consider environmental aspects of various projects and proposals" (Graham, 1976: 8). Procedures for considering these environmental aspects are described in Air Force Instruction (AFI) 32-7061, "Environmental Impact Analysis Process". The instruction discusses the steps that are required to comply with the NEPA, including a chapter on preparing and processing environmental documents.

Examples of Federal actions that require environmental analysis range from constructing a new building to developing a new weapon system. Some actions that are analyzed do not require excessive documentation, while others generate voluminous environmental impact statements. Environmental analysis documents fall into three categories. First, a Categorical Exclusion (CATEX) describes analysis of minor, repetitive actions. Second, an Environmental Assessment (EA) is used to analyze actions that are suspected to have major impacts. Finally, an Environmental Impact Statement is used to analyze actions that definitely have major impacts.

Thousands of Environmental Impact Analyses have been published since the passage of the NEPA. This documentation is designed to improve decision making with regard to environmental impacts. In the opinion of many experts, the requirement was long overdue for Federal agencies to consider environmental issues in their decisions. "For too long agency leadership had focused on economic and technical feasibility of a program or project but had ignored the environmental consequences of their actions. NEPA added the necessary third dimension" (Clark, 1993: 4).

**The Environmental Impact Analysis Process**

Environmental Impact Analysis involves four major steps: (1) identifying the activity, (2) identifying environmental attributes to measure, (3) measuring the impact of the activity on the attributes, and (4) reporting results (Jain, 1993: 83). Historically, many approaches have been used to report results, some with more success than others. Once the requirement existed to produce the documents, an exciting evolution of environmental analysis techniques occurred. As observed by the senior policy analyst in the office of General Counsel in the President's Council on Environmental Quality, this evolution included some growing pains:

> Certainly, many environmental impact statements are too long, take too long to prepare, cost too much, and many times do little to protect the environment. Some EISs are prepared to justify decisions already made, many agencies fail to monitor during and after the project, some agencies do not provide adequate public involvement, and few agencies assess the cumulative effects of an action. (Clark, 1993:4)

In any case, the process of considering environmental impacts is well understood by Federal agencies:

> NEPA was designed to change the ethic of federal agencies by fostering an integration of environmental considerations into the decision making process. To a great extent, this has happened. Certainly the agencies that produce the bulk of the EISs (the Forest Service, the Federal Highway Administration, the Bureau of Land Management, the Department of Defense and the Department of the Interior's Minerals Management Service) have well-established environmental components integrated throughout their planning and decision making processes. (Dickerson, 1993: 8)

In the Department of Defense, and the Air Force in particular, environmental analysis has become a key function in managing the planning for future programs.

## Pollution Prevention in the NEPA

While environmental analysis focuses on predicting future impacts, the use of Pollution Prevention (P2) actively attempts to prevent them. The P2 approach, defined in this section, is revolutionary compared to traditional practices of producing waste and treating it at the end of output pipelines. Many of today's environmental management advances are in the P2 arena. Yet even though the President's Council on Environmental Quality (CEQ) noted substantial improvements in environmental quality in the 20 years after the passage of the NEPA, the progress was limited to the area of waste cleanup. CEQ leadership noted that "... the challenge of the future is to prevent pollution in the first place. The CEQ believes that the NEPA foresaw that need, and the mandate to assess pollution prevention opportunities exists in Section 101 of the statute" (Clark, 1993: 5). Although twenty years elapsed before a specific pollution prevention law was passed, the origins of that law appear in the NEPA. Today, pollution prevention efforts are an integral part of the NEPA process.

## Defining Pollution Prevention

Despite its close relationship with the NEPA process, very little progress was made in the pollution prevention arena in the 1970s or 1980s. Eventually, as toxic chemicals accumulated in our environment, industry leaders acknowledged the need to change their approach to waste management. In the past two decades, environmental managers and scholars have coined several terms for what we now call pollution prevention. The list below contains terms that have been used to describe the P2 process (Freeman, 1995). This list is not exhaustive, but it gives some insight into the concepts embodied in the term pollution prevention:

| |
|---|
| Avoidance strategy |
| Humane Chemistry |
| Nonwaste technology |
| Pollution control technology |
| Recycling |
| Source reduction |
| Waste Avoidance |
| Waste minimization |

Regardless of the words used to describe the process, the act of reducing waste and protecting the environment should be the focus of any pollution prevention program.

In early 1990, industry publicly embraced the term pollution prevention. Since then the definition of pollution prevention has been widely debated. It was actually introduced in the 1984 Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act. Then, in its 1986 Report to Congress, EPA stated that waste minimization is:

> The reduction to the extent feasible, of hazardous waste that is generated or subsequently treated, stored or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste, or (2) the reduction of toxicity of hazardous waste, or both, so long as reduction is consistent with the goal of minimizing present and future threats to human health and the environment. (Comella and Rittmeyer, 1990: 71)

The EPA set a hierarchy of waste management that defines four broad categories including: (1) source reduction, (2) recycling, (3) treatment and, the least preferred method, (4) disposal. Price notes that when one looks at the range of options in the waste management hierarchy, the first preference is source reduction. In practice however, most manufacturers need to use the entire hierarchy to minimize the potential effects of their operations on the environment (Price, 1993: 93).

The EPA refined the definition of pollution prevention again in 1992. This time it stated,

> Pollution Prevention means 'source reduction', as defined under the Pollution Prevention Act, and other practices that reduce or eliminate the creation of pollutants ... Under the Pollution Prevention Act, recycling, energy recovery, treatment, and disposal are not included within the definition of pollution prevention. (Habicht, 1992)

If waste reduction is the goal, how do we measure our success at achieving the goal? Bush notes that although measurement is necessary to monitor the progress of a given pollution prevention strategy, it is not a straightforward task (Bush, 1992: 432). She further states that the complex task of measuring pollution prevention requires much thought about industry and site specific conditions. In this developing field, there is no 'one-size-fits-all' approach.

The need to assess progress in pollution prevention is clear. Yet, with such a wide array of organizations and stakeholders involved, no single measure of pollution prevention will suit everybody's needs. Indeed, there are often as many measurements of P2 success as there are interested parties. Freeman concisely describes the situation:

> As a relatively new field, measuring pollution prevention has not developed to the point where there are accepted techniques, indicators, or even definitions for making consistent and comparable estimates. Many of the data sources currently used in measuring pollution prevention were not designed for this purpose and it is unclear whether they adequately do the job. Also, the data available for measuring progress differs greatly from organization to organization.
> (Freeman, 1995:237)

**Pollution Prevention as an Environmental Planning Tool**

Pollution prevention is a relatively new approach to waste management, replacing the traditional idea of treating the waste we inevitably produce. When Congress passed the Pollution Prevention Act in 1990, decades of hard learned waste management lessons

were transformed into law requiring this fresh approach to environmental protection. Nearly five years later, pollution prevention policies are producing results. To illustrate this point, data collected by headquarters United States Air Force (USAF) show the progress of pollution prevention efforts. In the USAF alone, the amount of hazardous waste disposal was cut by over 60 percent between 1987 and 1994. However, as shown in Figure 1, there are still nearly 20,000 tons of hazardous waste being generated by the USAF each year (Murphy, 1995). This amount of waste still represents tremendous opportunity for further pollution prevention efforts.

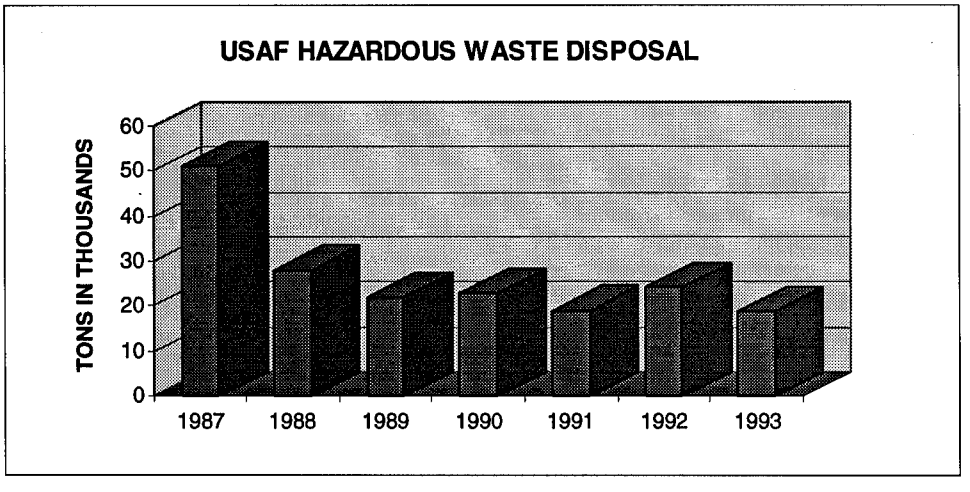



**Figure 1: Hazardous Waste Generation Data**

One potential area for pollution prevention is in the design and development of new weapons systems. While there are always pollution prevention concepts that can be adopted during the operational life of a weapon system, the best ideas come early in the process. This is when the greatest potential for pollution prevention exists. Aeronautical

Systems Center (ASC) notes, "The opportunities for incorporation of pollution prevention strategies diminish as acquisition phases are completed" (ASC, 1994: 2-2). Because the acquisition arena is fertile ground for pollution prevention, the USAF can reap benefits by reviewing recent aircraft development programs and determining to what extent pollution prevention opportunities were exploited. Lessons learned from recent weapon system acquisitions can provide Air Force leaders with helpful feedback regarding pollution prevention in the USAF.

In a 1989 memorandum for secretaries of the military departments, Secretary of Defense Dick Cheney charged the DoD to be the Federal leader in agency environmental compliance and protection (Cheney, 1989). As a result of the 1990 Pollution Prevention Act and the 1992 Federal Facilities Compliance Act, DoD is additionally challenged to lead the change to a pollution prevention culture. A benefit of this change is resultant improvement in environmental compliance because less pollution translates to better compliance. Alternatively, unfocused, ineffective pollution prevention initiatives may result in increased incidences of noncompliance. Compliance records can be used as an indicator of pollution prevention opportunities. Improvement areas can be identified through an in-depth investigation of the environmental compliance impacts of newly bedded down weapon systems at USAF installations. For example, a sudden increase in hazardous waste management violation notices at a base that is bedding down a new weapon system may be a signal that P2 was not optimally employed.

The concept of pollution prevention would not be particularly new or interesting in the 1990s if not for the unique combination of environmental events and legislation in the

1980s, which culminated with the Pollution Prevention Act (PPA) of 1990. Historically, the United States Environmental Protection Agency (USEPA) has enforced waste control regulations with violation notices and fines. It took the catalyst of financial demotivation to alert industry to the value of pollution prevention. The key point was that investments to minimize waste were only wise if they were profitable. In other words, pollution prevention was cost effective when it became expensive to pollute. When the PPA was passed, American manufacturers were spending nearly $50 million on pollution control measures and equipment, yet their waste disposal bills accounted for an even bigger slice of the corporate budget (Comella and Rittmeyer, 1990: 71). The PPA provided incentive to improve waste minimization processes.

Given that the cost of waste management is high, one might ask why the current pollution prevention revolution has taken so long to occur. The answer may be that until recently, our industry leaders felt no pressure to be responsible stewards of the environment. Interestingly, many industry people claim that pollution prevention has been practiced, under the name of yield improvement, for as long as there has been manufacturing (Price, 1993: 93). Now, however, there is more technology available to pursue a range of pollution prevention opportunities.

The pollution prevention opportunities today represent a very new approach to waste management. Historically, the waste produced by the aerospace industry was viewed as a necessary evil, and simply treated - if at all - at the point where it was released into the environment. This approach to waste management is often referred to as 'end of pipe treatment'. The problem with this approach is that it does nothing to promote responsible

waste handling or disposal. In fact, most waste treatment simply transfers hazard from one medium such as land, to another such as water or air.

The Earth has shown considerable ability to handle human discharges. However, the earth's capacity to heal is stressed to the breaking point when the net effect of millions of pounds of pollutants is taken into account. Prior to the Rio earth summit in 1993, Ramphal proclaimed that the message was clear: "Despite human accomplishments, Earth and all it sustains are endangered" (Ramphal, 1992: 3). It was not a new message, but it had acquired new authority and urgency with the recognition that human survival itself could be at risk. The Pollution Prevention Act is one sign that governmental leaders finally recognized the damage caused by the sum total of our waste.

**Green Design**

One way that environmental issues enter the acquisition process is up-front "Green Design". This term captures the idea of incorporating environmental concerns early in the conceptual stage of a product lifecycle. Congress' Office of Technology Assessment (OTA) defines green design as "a design process in which environmental attributes are treated as design objectives, rather than constraints" (OTA, 1992:7). The concept of green design can be effectively incorporated into early phases of the acquisition process, resulting in a more environmentally friendly weapon system. However, green design alone will not guarantee that there will be no environmental problems once a weapon system is fielded. Comprehensive environmental planning must be performed and the impacts of the weapon system must be considered.

## Weapon System Acquisition

Acquisition of weapon systems in the Department of Defense is a complicated undertaking, even before environmental objectives are incorporated into the process. "It is a methodological process, always trading off cost, schedule and performance in order to field the best weapon system to meet the threat" (Przemieniecki, 1993: 35). In theory, it is a relatively easy task to outline the process of providing weapon systems to meet mission needs. However, in practice there are many confounding factors. A logical first step in reviewing the acquisition process is to define its purpose. "The purpose of weapon systems acquisition is to provide the operational user with a capable, supported and affordable weapon system and to deliver the system when and where it is needed" (Schoonover, 1994: 7). The concept of a weapon system includes both the weapon and its logistics support. All weapon systems, from the simplest to the most complex, follow a process that includes phases and milestones described below.

## The DoD Acquisition Process

"The acquisition process provides a means of progressively translating broadly stated mission needs into well-defined-system-specific requirements" (Przemieniecki, 1993: 20). This process includes four phases, each preceded by a milestone decision review. Milestone reviews are analogous to gateways between acquisition phases. "At the milestone review, the accomplishments of a program in the previous phase and its readiness to enter the next phase are assessed. The primary document used in this review is the Integrated Program Summary (IPS)" (Schoonover, 1994: 8). An IPS contains

critical environmental impact information. The Acquisition Pollution Prevention AFMC Implementation Guide notes that:

> Milestones require extensive documentation detailed in the Integrated Program Summary (IPS). The IPS format is called out in DoD 5000.2-M (Part 4). An environmental analysis is required as Annex E of the IPS. Details concerning preparation of the environmental analysis are contained in DoDI 5000.2, Part 6-1. (Air Force Materiel Command, 1993: A-3)

In addition to environmental issues, the IPS contains information about a wide range of topics including life cycle cost and contracting strategy. Based on this information, the program review board establishes goals for the next acquisition phase. These goals will be review criteria for the following milestone. When criteria are met, the program exits one phase and enters the next. DoD weapon system acquisition phases and milestones are shown in Figure 2 (Air Force Materiel Command, 1993).

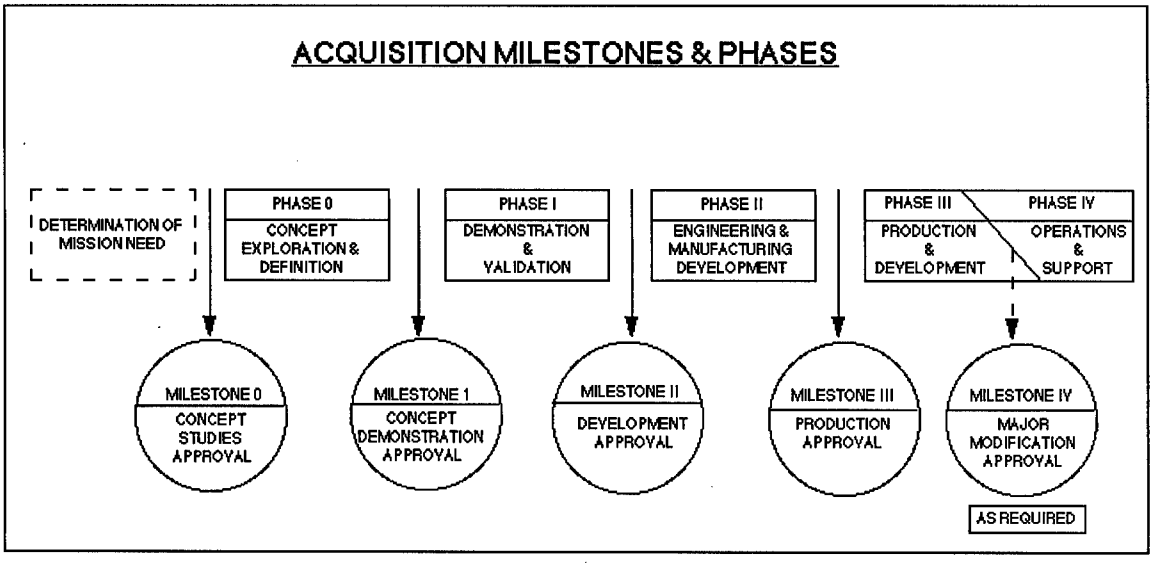



**Figure 2: The Acquisition Process**

The environmental planning efforts for weapon systems continue to focus on two areas: impacts and pollution prevention (Nelson, 1995). Impacts must be considered in environmental analyses that identify environmental effects in detail. "To comply with applicable environmental protection laws and regulations, an environmental analysis of new defense systems will begin at the earliest possible time" (Przemieniecki, 1993: 330). This analysis is incorporated into a Programmatic Environmental Assessment (PEA) that is an integral part of the IPS described above. Currently, updated environmental analysis are performed and added to the PEA at each milestone.

While pollution prevention is a subset of environmental planning concerns, it provides an powerful tool for reducing impacts. DoD officials know that early environmental planning and P2 efforts can have lasting payoffs:

> Decisions made during concept exploration and definition, demonstration and validation, engineering and manufacturing development, and the production phases of the acquisition process directly influence the cost of managing material and waste streams for production contractors, depots, and installations that maintain and operate the systems. They also affect the cost to the Air Force of disposing of the system at the end of its useful life. Decisions made during the acquisition process leave a legacy that lasts long after acquisition is completed. (Przemieniecki, 1993: 325)

**The C-17 Acquisition**

The C-17 acquisition occurred during a period when environmental regulations were increasing exponentially. Long before the Pollution Prevention Act was passed, engineers at Aeronautical Systems Division (ASD) were performing environmental analysis of the C-X aircraft, which eventually became the C-17. In 1981, ASD staff environmental planners

completed an environmental assessment for the C-X which described the proposed aircraft as follows:

> The C-X will be a multi-engine turbofan wide body aircraft capable of airlifting a substantial payload over intercontinental ranges without refueling and will be specifically designed to move outsized combat equipment/cargo into and within an austere airfield/moderate threat environment. The aircraft will be equipped with receiver inflight refueling capability to increase its range/payload capacity. Current direction for the program is provided by Program Management Directive (PMD) #RC 0020(1), dated 22 April 1981. (Department of the Air Force, 1981:1)

At this time, the program was in Phase I, preparing for Milestone II. The passage of Milestone II into Phase II occurred when Full Scale Development (FSD) was approved by the Secretary of Defense in February of 1985 (Miller and Williams, 1993: 151). When McDonnell Douglas Corporation began fabricating the first C-17 in November 1987, the only historical environmental documentation was the C-X assessment. ASD personnel in the C-17 SPO began work on a supplemental programmatic EA in May 1989. The purpose of this document was to update the original C-X environmental assessment. At the same time planners at Military Airlift Command were preparing an environmental assessment for the beddown of the C-17 at Charleston AFB. This document contained much more detail than the programmatic EA. Air Force System Command legal staff would later reject ASD efforts to publish a final draft of the programmatic EA. Meanwhile, the Defense Acquisition Board made the Milestone IIIA low rate initial production decision in January 1989. Due to intense Congressional scrutiny and oversight of the C-17 program, it was not until June 1993 that the first C-17 arrived at Charleston

AFB. In the interim, Air Force personnel had the opportunity to work extensively with McDonnell Douglas to improve C-17 environmental planning.

**Significance of Environmental Planning in Acquisition**

The relationship between defense acquisition and environmental management has been explored since the passage of the NEPA. As early as 1976, the Defense Systems Management School outlined the impact of environmental regulations on defense system acquisition management. The report concluded that "the impact of environmental regulations is a significant factor that should be considered by defense system programmers as early in the program as possible" (Graham, 1976:ii). Despite this realization, the Department of Defense took little action to rigorously improve acquisition environmental management until the early 1990s.

The acquisition community has a large capacity for either causing or mitigating environmental impacts during the development of new weapon systems. In an audit report issued in December 1993, the Department of Defense Inspector General (DoDIG) addressed the effectiveness of DoD environmental planning in acquisition programs. The DoDIG issued the following three findings:

a. Environmental oversight was not fully effective.

b. There was a failure to assess programmatic environmental tradeoffs when conducting Cost and Operational Effectiveness Analyses.

c. An accurate estimate for environmental clean-up and remediation liabilities of Defense contractors has not been fully developed.

The lesson here is that environmental concerns need to be integrated into the acquisition decision making process (Noble, 1994).

The Air Force needs to know the effectiveness of environmental programs in weapon system acquisition. Currently, the author is aware of no similar research that concentrates on the result of environmental planning for a weapon system. Little guidance exists that discusses what happens after required NEPA documentation is completed. Current practice for weapon system development in the Air Force is to prepare a generic environmental planning document for the program, then conduct specific environmental planning for the beddown location. With a new focus on pollution prevention during design, it may be more appropriate to conduct more in-depth environmental planning up front. As a result of early consideration of environmental impacts, and application of green design, we can reap benefits such as reduced use of hazardous materials and less generation of hazardous waste.

**Summary**

This chapter reviewed the National Environmental Policy Act, Pollution Prevention, DoD weapon system acquisition, and key acquisition milestones for the C-17. The role of environmental planning in acquisition was explored. The next chapter will consider the evidence that shows whether environmental planning was effective for the C-17 at Charleston AFB.

# III. Methodology

## Chapter Overview

This chapter outlines the research approach used to collect and analyze information regarding the relationship between environmental planning and the DoD acquisition process. The methodology used to answer the research questions included the following:

a. evidence collection,

b. an environmental postaudit of C-17 planning, and

c. construction of a framework for environmental planning in acquisition.

This approach studies the acquisition of the C-17, highlights environmental issues related to the aircraft, and reviews the timing of planning and decision making.

## Research Questions

This research was designed to answer the four questions which were discussed in the introductory chapter. Because these questions drive the methodology, they are repeated below:

| |
|---|
| 1. What environmental problems occurred during the beddown of the C-17 at Charleston Air Force Base (CAFB)? |
| 2. Which, if any, CAFB environmental problems resulted from unique local environmental requirements or conditions? |
| 3. How were CAFB environmental issues addressed during the C-17 acquisition process? |
| 4. What lessons learned from the C-17 beddown at CAFB can be applied to other weapon system beddowns? |

These questions provided the focus for evidence collection at Charleston AFB and follow-up background research in the acquisition community at Aeronautical Systems Command (ASC) at Wright Patterson AFB. Information was collected during June 1995 with follow-up in August and September 1995. The process for evidence collection is discussed in detail below.

## Data Collection Methodology

A large portion of the information collected during this research effort occurred at Charleston AFB during an intensive week of evidence collection from 22-30 June 95. Three sources of evidence, described by Yin (1989:85) were the focus of data collection for this case study. These included documentation, interviews and direct observations.

**Documentation Evidence.** Examples of documentation evidence included environmental correspondence, meeting minutes from C-17 conferences, press releases and news articles. These documents were primarily useful for corroborating other evidence obtained from observations and interviews. Additionally, several key aircraft deployment (beddown) documents were reviewed for data regarding environmental planning and observed impacts of this major federal action. Documents reviewed include the environmental impact analysis documents prepared for the C-17 and the specific Charleston AFB beddown Environmental Assessments. Base spill plans were reviewed, along with other environmental documents such as the hazardous waste management plan, permit applications and any applicable environmental notices of violation.

All documents were organized using a checklist prepared by the researcher. This checklist is in Appendix A. Documents were sorted by date and subject to allow for more convenient analysis. Document review occurred approximately two years after deployment of the initial C-17 aircraft at CAFB.

**Interviews.** Over 25 interviews were conducted with installation personnel to collect information regarding environmental planning predictions compared to actual field experience. A list of interviewed individuals, and the interview protocol can be found in Appendix B. Standard introduction questions regarding job title and time in position were used to begin interviews. Every interview included four questions which encouraged discussion about the Charleston AFB environmental program and the C-17. For example, interview participants were asked to describe how the C-17 beddown affected them on a scale of one to ten. Responses are listed in Appendix B. Follow-up questions were asked depending on individual experience level. Interviews were conducted with base personnel who could be expected to possess information regarding environmental impacts of a new weapon system.

Yin's interview techniques were applied to optimize information flow. Focused, open-ended interviews were employed to obtain facts and opinions from personnel at CAFB. The value of these type interviews is that they allowed key people at Charleston to provide evidence about the C-17 beddown. These people "not only provide the case study investigator with insights into a matter, but can also suggest sources of corroboratory evidence - and initiate the access to such sources" (Yin, 1989: 89).

The Air Force Environmental Compliance Assessment and Management Program (ECAMP) manual provides guidance regarding personnel to contact while conducting environmental investigations. Using this guidance, and personal experience, the researcher generated a list of the following personnel to interview:

- Bioenvironmental Engineers
- C-17 Deployment Coordinators
- C-17 maintenance chiefs
- Civil Engineers
- Emergency response personnel
- Environmental Management Staff
- Local Environmental Regulators
- Public Affairs Officer
- Safety Office Representatives
- Supply Personnel
- Transportation Personnel

Interviewees were selected because their positions made them likely to observe impacts caused by the beddown of a new aircraft. Their unique perspectives can be used as input in the environmental planning process. Interviews were structured to allow interviewees to relate experiences, share data and make suggestions regarding other information sources. Interviews were conducted to explore both objective and subjective attitudes toward the success of environmental planning in the weapon system and potential for improvement.

**Representativeness of the C-17 Acquisition Program**

The C-17 is only one of many weapon systems which have been subject to NEPA requirements during their acquisition. Each weapon system is unique. The C-17

acquisition program is appropriate for study because it is the most recent major weapon system bedded down at an Air Force installation. General inferences can be made from this study inasmuch as there are facets of the acquisition process common to all weapon systems.

## Answering the Research Questions

With evidence collected, three major analysis techniques were used to answer the research questions. An environmental postaudit was used to answer questions one and two. This postaudit is described in detail below. An acquisition environmental framework was constructed to answer question three, further, an evaluation of the beddown documentation was conducted to determine the quality of environmental planning for the C-17. The fourth research question was answered by analyzing the information presented for the first three questions.

**Environmental Postauditing.** The environmental postaudit for the C-17 acquisition and beddown involved comparing actual environmental impacts with those predicted in environmental planning documents. Actual impacts of the C-17 were observed during the data collection at Charleston AFB. Several sources of information were examined, and all data collected was compared with forecasted trends. For example, waste generation predicted in beddown planning documents was compared with actual field experience. Comparison areas were taken directly from the CAFB beddown Environmental Assessment. Section 3 of that document is entitled "Affected Environment". It discusses

impacts in ten broad categories. Environmental Consequences that were predicted in this document included the following ten categories:

| |
|---|
| General |
| Air Quality |
| Noise |
| Water Quality and Usage |
| Solid Waste/Sewage |
| Cultural Resources |
| Socioeconomics |
| Utility Usage |
| Construction |
| Unresolved Issues |

The ten categories in the Environmental Assessment were expanded to a list of eleven categories for analysis. For example, Solid Waste and Sewage were analyzed as separate categories, whereas the 'General' category was classified and therefore not analyzed. If an impact occurred in a given category, several questions were asked to identify the root causes that contributed to the impact. The researcher was interested in determining the extent to which local conditions influenced environmental impacts. Evidence was examined to determine if other root causes could be identified. Each Category was evaluated to answer the following questions:

| |
|---|
| 1. Was there an environmental impact? |
| 2. If there was an environmental impact, was it positive or negative? |
| 3. Were predictions accurate? |
| 4. If there was an environmental impact, was it because of local conditions, or could it have been expected to be an impact at any Air Force Installation? |
| 5. If there was an environmental impact, was it an issue that involved timing of information flow from aircraft developers to the field? |
| 6. If there was an environmental impact, was funding a factor? |
| 7. Were impact mitigation measures considered by the System Program Office? |

The eleven categories are shown in Table 1. These categories and analysis questions form a matrix to grade the accuracy of environmental documentation. The matrix lists the factors that identify root causes of impacts. For example, if an impact occurred that was based solely on local conditions, this information can be determined from a cursory inspection of the matrix.

**TABLE 1: Matrix of Environmental Categories and Evaluation Areas**

| CATEGORY | Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|---|
| Air Quality | | | | | | |
| Noise | | | | | | |
| Water Quality | | | | | | |
| Water Usage | | | | | | |
| Solid Waste | | | | | | |
| Sewage | | | | | | |
| Cultural Resources | | | | | | |
| Socioeconomics | | | | | | |
| Utilities | | | | | | |
| Construction | | | | | | |
| Unresolved Issues | | | | | | |

Evidence from Charleston AFB was gathered in order to judge whether an impact was positive, negative or negligible. Negative impacts were indicated by one or more problems for a given category. Definitions from the Air Force Environmental Compliance Assessment and Management Program (ECAMP) were used to identify problems at the base. ECAMP defines three types of environmental problems. Significant problems pose immediate danger to humans or the environment, and usually result in a Notice of Violation (NOV). Major problems are serious, but do not present immediate threat. Minor problems are typically administrative in nature and can be easily fixed. These

problems are often documented in ECAMP reports or through NOVs from local regulators.

**Constructing a Framework for Environmental Planning in Acquisition.** The second step in the methodology involved using historical data to construct a framework for evaluation of C-17 environmental planning. The objective of this exercise was to determine what guidance existed for acquisition environmental planners in the 1980s. Once this framework was constructed, the actual experience of the C-17 program could be compared against it. This was accomplished by conducting interviews and reviewing documentation at the C-17 SPO and Aeronautical Systems Command (ASC) Headquarters at Wright-Patterson AFB.

This research reviewed the major milestones of the C-17 acquisition and explored where environmental planning fit into that process. Using case study guidance provided by Yin (1989), planning documents such as the Programmatic Environmental Assessment and CAFB C-17 Beddown Environmental Assessment were analyzed to determine the following:

a. When was the planning accomplished?
b. Who did the environmental planning?
c. What guidance was used?
d. Did the planning documents appear to be complete?
e. What impacts were predicted by environmental documentation?
f. How did environmental planning fit into the acquisition process?

Based upon available guidance, a flow chart of model environmental planning steps for acquisition and beddown is presented in Appendix C. To put the actual C-17 acquisition process in perspective, significant events, such as major milestones and completion of environmental documents, were compiled into a timeline. This timeline is presented in Appendix D. It was a useful tool for analyzing the environmental planning for the weapon system.

**Evaluating the Quality of Environmental Documentation.** Key documentation regarding the extent of environmental planning during the C-17 acquisition process are Environmental Assessments. One EA was prepared for the C-17 program and one EA was prepared specifically for Charleston AFB. The Charleston EA was evaluated using criteria developed by Jain (1993). The programmatic EA was not similarly evaluated but is discussed separately. Twenty criteria described by Jain to evaluate the quality of environmental documentation are listed below. The evaluation criteria address key issues with environmental assessment: (1) impact identification, (2) impact measurement, (3) impact interpretation and (4) impact communication (Jain, 1993:120).

**Evaluating Impact Identification**. The criteria used to evaluate impact identification included the following:

*Comprehensiveness*: A full range of direct and indirect impacts should be addressed, including ecological, physical-chemical pollution social-cultural, aesthetic, resource supplies, induced growth, regional economy, employment, induced population or wealth redistributions, and induced energy or land use patterns

*Specificity*: The methodology should identify specific parameters (subcategories of impact types), i.e. detailed parameters under the major environmental categories of air, water, ecology, etc., to be examined

*Isolate project impact*: Methods to identify project impacts, as distinct from future environmental changes produced by other causes, should be employed.

*Timing and duration*: Methods to identify the timing (short-term operational versus long-term operational phases) and duration of impacts should be employed.

*Data sources known*: Identification of the data sources used to identify impacts should be required. Data sources should also be listed for impact measurement and interpretation.

**Evaluating Impact Measurement**. The criteria used to evaluate impact measurement included the following:

*Explicit indicators*: Specific measurable indicators to be used for quantifying impacts on parameters should be used.

*Magnitude provided*: The methodology should provide for measurement of impact magnitude, as distinct from impact significance.

*Objective measurement*: Objective rather than subjective impact measurements should be emphasized. Professional judgments should be identified as such, although they may be the only criteria available in many cases.

**Evaluating Impact Interpretation.** Evaluation of the interpretation and communication criteria is a more subjective exercise than evaluation of identification and measurement criteria. Impact interpretation issues appear to relate to the spirit of the NEPA rather than the letter of the law. Analysis of these criteria provided insight into whether the environmental assessment was a decision making tool or simply a documentation requirement. Similarly, analysis of the impact communication criteria indicated whether or not the documentation was prepared for public review.

The criteria used to evaluate impact interpretation included the following:

*Significance scaled*: Explicit assessment of the significance of measured impacts on a local, regional and national scale should be provided.

*Criteria explicit*: A statement of the criteria and assumptions employed to determine impact significance should be required.

*Uncertainties made known*: An assessment of the uncertainty or degree of confidence in impact significance should be required.

*Risks identified*: Identification of any impacts having low probability but high damage or loss potential should be required.

*Alternatives compared*: A specific method for comparing projects, including the no action alternative, should be provided

*Impacts aggregated*: The methodology should provide a mechanism for aggregating impacts into a net total or composite estimate. If aggregation is included, specific weighting criteria or processes to be used should be identified.

*Public involvement seen*: The methodology should include a mechanism for public involvement in the interpretation of impact significance.

**Evaluating Impact Communication.** The criteria used to evaluate impact communication included the following:

*Affected groups visible*: A mechanism for linking impacts to the specific geographical areas or social groups should be required and suggested.

*Setting described*: A methodology should require that the project setting be described to aid statement users in developing adequate overall perspective.

*Format for summary*: A format for presenting, in summary, the results of the analysis, should be provided.

*Key issues highlighted*: A format for highlighting key issues and impacts identified in the analysis should be provided.

*Match NEPA regulations*: Guidelines for summarizing results in terms of the specific points highlighted in NEPA and CEQ regulations should be provided.

Although these criteria were originally created to evaluate different approaches to environmental assessment, they are equally as effective in evaluating already completed assessments. Table 2 shows the scores in each category (Jain, 1993:123).

**Table 2: Evaluation Criteria Scoring System**

| Score | Interpretation |
|---|---|
| Y | Yes (Meets Criteria). |
| M | Marginal (Partially meets criteria). |
| N | No (Does not meet criteria or minimally meets criteria). |

Table 3 contains a listing of the 20 criteria and a column format for scoring environmental assessments.

**Table 3: Environmental Document Evaluation Criteria**

| CRITERIA | SCORE (Y/M/N) |
|---|---|
| Comprehensiveness | |
| Specificity | |
| Isolate project impact | |
| Timing and duration | |
| Data sources known | |
| Explicit indicators | |
| Magnitude provided | |
| Objective measurement | |
| Significance scaled | |
| Criteria explicit | |
| Uncertainties made known | |
| Risks identified | |
| Alternatives compared | |
| Impacts aggregated | |
| Public involvement seen | |
| Affected groups visible | |
| Setting described | |
| Format for summary | |
| Key issues highlighted | |
| Match NEPA regulations | |

## Summary

Using published guidance regarding data collection and analysis methodologies, a plan was developed to collect and organize information regarding the beddown of the C-17 at Charleston AFB. The methodology described in this chapter was used to directly answer the first three research questions. This information was combined to answer question number four. Results are reported in chapter 4, Analysis.

# IV. Analysis

## Chapter Overview

This chapter presents the results of employing the methodology described in chapter three. Research questions were answered through a series of tasks which examined the environmental impacts of the beddown of the C-17 at Charleston AFB, compared them to predicted impacts, and finally evaluated the quality of the environmental planning documents themselves. The role of environmental planning in the acquisition process was explored by building a framework of ideal planning and comparing actual field experience against that background. The information collected was used to make inferences about acquisition environmental planning. Those inferences are discussed in the following chapter.

## Environmental Impacts At Charleston AFB

The initial two research questions ask:

1. What environmental problems occurred during the beddown of the C-17

2. Which, if any, CAFB environmental problems resulted from unique local environmental requirements or conditions?

Information collected at Charleston AFB in June 1995 was indexed and organized to determine if there were any significant, major or minor environmental problems caused by the beddown of the C-17. Evidence was analyzed using the definitions of significant, major and minor findings described in the AF Environmental Compliance Assessment and Management Program manual. The results of this analysis are presented below.

No significant or major environmental problems were reported for Charleston AFB during the first two years of the beddown. Additionally, no Notices of Violation (NOVs) were issued to CAFB that can be attributed to the C-17. One example of a minor problem was the disposal of large amounts of hazardous material because its shelf life had expired. Prior to proper labeling and disposal, the unusable material could have been construed as improperly stored hazardous waste. Fast action by the base environmental office and hazardous material pharmacy avoided a possible compliance violation.

Environmental categories that were evaluated are summarized in Table 4 below.

**Table 4. Environmental Impacts of the C-17 at CAFB**

| CATEGORY | Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|---|
| Air Quality | + | Y | N/A | N/A | N/A | Y |
| Noise | + | Y | Y | N/A | N/A | Y |
| Water Quality | 0 | Y | N/A | N/A | N/A | N |
| Water Usage | 0 | Y | N/A | N/A | N/A | N |
| Solid Waste | - | N | N | N | N | Y |
| Sewage | 0 | Y | N/A | N/A | N/A | N |
| Cultural Resources | 0 | Y | N/A | N/A | N/A | N |
| Socioeconomics | + | Y | Y | N/A | N/A | N |
| Utilities | 0 | Y | N/A | N/A | N/A | N |
| Construction | - | N | N | Y | Y | N |
| Unresolved Issues | 0 | Y | N/A | N/A | N/A | N |

Each category is discussed in detail in the following section. For each category, environmental impact was determined based upon available evidence. This evidence, presented in paragraph form, refers to interviews, documents and observations listed in the bibliography of this report. Where impacts were observed, several possible root causes were explored to determine if the impacts could have been reduced or eliminated.

**Air Quality**

The C-17 had a positive impact on air quality at CAFB. Although portions of the beddown Environmental Assessment remain classified, the C-17 programmatic EA contains useful information for comparison of predicted versus actual impacts in the air quality arena. The positive impact is due to the fact that newer F-117 engines on the C-17 produce less emissions than the TF-33 engines on the C-141 aircraft they replaced (South Carolina Department of Health and Environmental Control (SCDHEC), 1994).

The beddown EA effectively described the existing environment, noting regulatory requirements and local conditions. At the time the EA was prepared, air quality in Charleston county was within standards for all pollutants. This was also true during the case study research period. The EA reported that except for carbon monoxide, CAFB emissions were generally small compared to point source emissions in Charleston County. In fact, based on Charleston County point source emissions for 1988, "military aircraft at Charleston AFB amount[ed] to 72% of the county's CO emissions, 14.6% for hydrocarbons (HC), 10.6% for $NO_x$ , 0.42% for [Total Suspended Particulates] and 0.57% for $SO_2$" (Department of the Air Force, 1989: 8).

Review of emissions data and an interview with the CAFB air program manager (Powell, 1995) confirmed relatively low quantity of air emissions. This information was corroborated in an interview with the District Director of the South Carolina Department of Health and Environmental Control (Fanning, 1995). Table 5 contains a summary for air quality impacts.

**Table 5: Summary of Air Quality Impacts**

| Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|
| + | Y | N/A | N/A | N/A | Y |

### Noise

The C-17 had a positive impact on noise at CAFB. The C-17 has quieter engines than the C-141 it replaced (LPA Group, 1993). This was explained in the EA and confirmed during document review and interview with the CAFB community planner (Youngblood, 1995). Further discussion of the improved engines appears in the Charleston AFB Joint Land Use Study prepared in 1993:

> With reference to the airfield, the introduction of the new C-17 Globemaster III aircraft takes advantage of the latest noise emission reduction and fuel efficiency technological advances available. This aircraft is substantially quieter than previous large military aircraft types based at the airfield, and demonstrates the military's commitment to the aircraft noise impact reduction and abatement program, within the limits of new and available technology.
> (LPA Group, 1993: 3-2).

No discussion of noise impacts was included in the earliest environmental planning documents prepared by ASD in 1981. It was clear early on that the newest cargo jet would benefit from technological advances in noise abatement. Table 6 contains summary information regarding the impacts of the C-17 and how these compare with predictions.

**Table 6: Summary of Noise Impacts**

| Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|
| + | Y | Y | N/A | N/A | Y |

### Water Quality

The C-17 had no observable impact on water quality at CAFB. The environmental assessment predicted no impacts at CAFB, and this was confirmed by interviews with local regulators (Fanning, 1995). Table 7 summarizes water quality impacts.

**Table 7: Summary of Water Quality Impacts**

| Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|
| 0 | Y | N/A | N/A | N/A | N |

### Water Usage

The C-17 had no observable impact on water usage at CAFB. This was as predicted in the environmental assessment, which based its analysis on the assumption that there would be a small number of personnel at CAFB. Table 8 shows water use at Charleston AFB for the period Jan 1992-May 1995 (Beneway, 1995).

**TABLE 8: Monthly Water Use (KGAL), Charleston AFB, South Carolina**

| | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|
| **Jan** | 29627 | 18343 | 29019 | 37812 |
| **Feb** | 19960 | 15730 | 21349 | 23248 |
| **Mar** | 18002 | 25452 | 24934 | 27796 |
| **Apr** | 20655 | 28613 | 33099 | 25159 |
| **May** | 21002 | 27269 | 43939 | 31683 |
| **Jun** | 24104 | 43910 | 34578 | |
| **Jul** | 25760 | 39282 | 33909 | |
| **Aug** | 22348 | 31692 | 21443 | |
| **Sep** | 10617 | 27648 | 28003 | |
| **Oct** | 25080 | 27067 | 21230 | |
| **Nov** | 16832 | 24859 | 16445 | |
| **Dec** | 17107 | 20906 | 21556 | |

A graphical presentation of the water usage is shown in Figure 3.

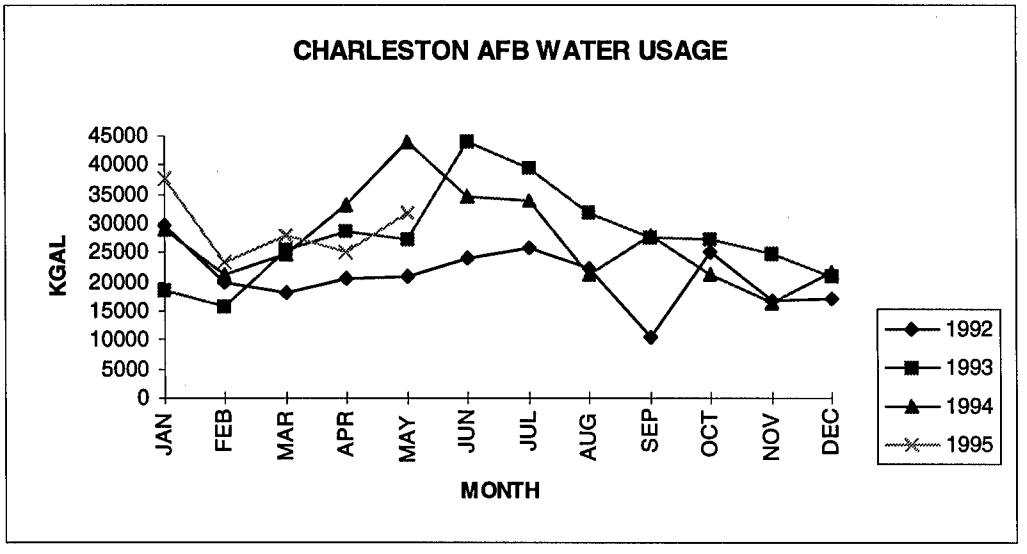



**Figure 3: Annual Comparison of Water Usage at CAFB**

One-way analysis of variance was used to determine if the differences in mean water use per month were statistically significant. The analysis is contained in Appendix E. It shows that there was no statistically significant change in water use from 1992-1995. The environmental assessment predicted a decrease in water use of approximately 3900 Kgal/month. This is a very small decrease compared to the monthly average of over 25,000. In fact, water usage increased slightly during the analysis period, though the increase was not statistically significant. Table 9 summarizes water usage impacts.

**Table 9: Summary of Water Usage Impacts**

| Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|
| 0 | Y | N/A | N/A | N/A | N |

### Solid Waste

The C-17 had no observable impact on nonhazardous solid waste production at CAFB, but caused minor hazardous waste disposal problems. The EA predicted that solid waste production would decrease by approximately 1759 pounds per day. This equates to approximately 26 tons less waste each month, or over 315 tons per year. "Minor reductions of solid waste would be expected from the withdrawal of personnel and their families. The estimated number of personnel involved, including families [was] 533" (Department of the Air Force, 1989: 54).

Actual solid waste generation is shown in Table 10 (Pape,1995). Hazardous waste generation is shown in Table 11 (Cummings, 1995). No predictions are made regarding hazardous waste, which is often a subset of solid waste. In fact, hazardous waste is not referenced at all in the EA. Remarkably, acquisition personnel performed in depth pollution prevention planning shortly after the EA was published. This is discussed further in the conclusion chapter of this thesis. No documents from Aeronautical Systems Center contain discussion of solid waste issues.

**Table 10: Solid Waste Generation**

| | FY92 | FY93 | FY94 | FY95* |
|---|---|---|---|---|
| Tons | 3964 | 3912 | 4119 | 3940 |

* - Projected based on 8 months generation records

**Table 11: Hazardous Waste Generation**

| | FY92 | FY93 | FY94 | FY95** |
|---|---|---|---|---|
| Tons | 154 | 116 | 150 | 129 |

** - Projected based on 6 months generation records

One of the few problems observed at Charleston AFB involved hazardous waste disposal. McDonnell Douglas C-17 maintenance personnel stored hazardous materials beyond the listed shelf life and were unaware of proper disposal procedures. The quantity and type of hazardous material was sufficient to warrant a Notice of Violation if discovered by environmental regulators. Additionally, the chemicals presented a safety hazard. However, fast action by the environmental office and the hazardous material pharmacy righted the situation. Disposal was expedited for the cache of hazardous materials.

CAFB records show that McDonnell Douglas disposed of 2600 pounds of hazardous material from 18 April 1995 through 8 June 1995. More than two thirds of this was outdated hazardous material. Overall, McDonnell Douglas turned in 3230 of the 13,238 pounds of hazardous waste generated by the C-17 (Pape, 1995). Hazardous material management has improved significantly since the discovery of the outdated material. McDonnell Douglas representatives quickly adopted better procedures for ordering, storing and disposing hazardous material. Lessons learned from this experience are discussed in the conclusion chapter of this thesis.

Table 12 summarizes solid waste impacts at CAFB.

**Table 12: Summary of Solid Waste Impacts**

| Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|
| - | Y | N | N | N | Y |

**Sewage**

The C-17 had no observable impact on sewage at CAFB. The data in Table 13 reflects wastewater produced at Charleston AFB for the period Jan 1992-May 1995 (Beneway, 1995).

**TABLE 13: Monthly Wastewater Production (KGAL), Charleston AFB, South Carolina**

| | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|
| **Jan** | 46385 | 38807 | 20446 | 44917 |
| **Feb** | 46385 | 30876 | 23577 | 33289 |
| **Mar** | 46328 | 23758 | 21993 | 33334 |
| **Apr** | 46328 | 34227 | 29087 | 33334 |
| **May** | 46329 | 28108 | 21190 | 24151 |
| **Jun** | 33662 | 22585 | 27363 | |
| **Jul** | 26182 | 18733 | 30127 | |
| **Aug** | 30670 | 11030 | 34341 | |
| **Sep** | 34422 | 21240 | 37592 | |
| **Oct** | 28035 | 19651 | 49256 | |
| **Nov** | 26587 | 27039 | 30836 | |
| **Dec** | 27039 | 21183 | 31288 | |

The CAFB Environmental Assessment predicted a decrease in wastewater production of approximately 1481 Kgal/Month. This compares to a monthly mean of 30,850 Kgal/Month during the period of analysis.

One-way analysis of variance was used to determine if the annual differences in mean wastewater production per month were statistically significant. The analysis shows that 1993 sewage production was significantly lower than 1992 production. However 1994 and 1995 numbers were not significantly different from 1992. Possible reasons for the decrease in 1993 are discussed in the conclusion chapter.

A graphical presentation of the sewage is shown in Figure 4.

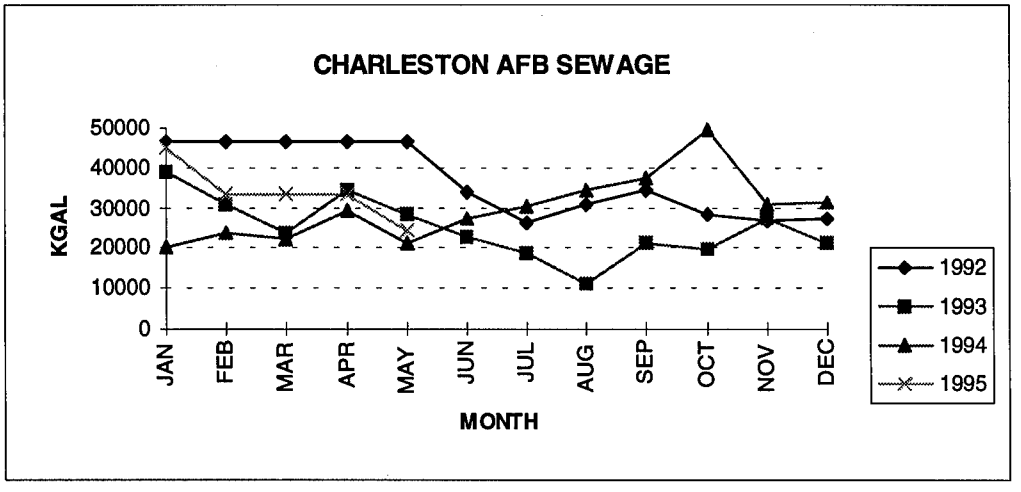



**Figure 4: Annual Comparison of Sewage at CAFB**

There is no record that the C-17 SPO, or ASD ever considered sewage impacts in early environmental analysis. Nor does there appear any need for such consideration. Table 14 presents a summary of sewage impacts.

**Table 14: Summary of Sewage Impacts**

| Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|
| 0 | Y | N/A | N/A | N/A | N |

### Cultural Resources

The C-17 had no observable impact on cultural resources at CAFB. Cultural resources include "the sum of historic, archeological, native American and other resources which antedate modern American Culture (generally 1950, with some

exceptions)" (Jain, 1993: 292). These resources are typically protected from certain activities by the National Historic Preservation Act. None of the C-17 beddown activities impacted cultural resources at CAFB (Youngblood, 1995). Table 15 summarizes the cultural resource impacts at Charleston AFB.

**Table 15: Summary of Cultural Resource Impacts**

| Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|
| 0 | Y | N/A | N/A | N/A | N |

### Socioeconomics

The C-17 had a positive impact on socioeconomics at CAFB. The local economy had been impacted by the loss of jobs from the closure of Charleston Naval Shipyard, and the beddown of the C-17 generated revenues to help offset that loss.

The Environmental Assessment broke the socioeconomic analysis into five components. These included (1) Population, (2) Secondary Jobs, (3) Other Socioeconomic Effects, (4) Prime Farmland and (5) Installation Restoration Program. Because a reduction in personnel was expected at the base, the environmental assessment predicted a small impact on local business, offset by an increase in construction investment during the beddown.

Cumulative effects of mission change with related federal activities such as Charleston Naval Shipyard were not discussed in the environmental assessment.

The EA reported:

> The population of the Charleston region in 1980 was 430,462 and the projection for 1990 was 541,300. If all the personnel whose manpower authorizations are lost in this action leave the area, the change is -0.09% of the 1990 projection.
>
> Because of the secondary economic impacts, we would expect a loss of 353 secondary jobs in the region.
>
> We expect changes in other areas, such as reductions in the revenues, federal impact aid to education as well as state education funds; charitable contributions; minor reductions in housing demand, etc ... There will also be beneficial impacts expected due to construction.
>
> This action will not cause a decrease in prime farmland being used for agricultural purposes.
>
> This proposal will not affect the IRP. (Department of the Air Force, 1989: 55).

The 1995 Commander's Summary was a document released by the 437th Airlift Wing to provide "an overview of the major development considerations" (Department of the Air Force, 1995: 1). It provided a base profile and Charleston area profile with socioeconomic factors similar to those discussed in the 1989 environmental assessment. Some facts from this document include:

> From 1980 to 1990, Charleston County grew by 18,483 people (7 percent) to an estimated population of 295,039. The population of North Charleston grew by 7,739 people (12 percent) between 1980 and 1990 to a total population of 70,218.
>
> Charleston County, including Charleston AFB, had a civilian labor force of 144,600 people in 1993, of which 135,750 [93.9%] were employed.
>
> Approximately 4,600 active-duty military personnel, 2,900 reservists and 1,225 civilians are assigned to, or employed by Charleston AFB. The combined military, reservist and civilian workforce is approximately 8,725, which is nearly 28 percent of the estimated 31,000 military personnel in the Charleston area. (Department of the Air Force, 1995: 1).

The difficulty in comparing environmental assessment predictions with actual data from 1995 is discussed in the conclusion chapter of this thesis. Table 16 summarizes socioeconomic impacts.

**Table 16: Summary of Socioeconomic Impacts**

| Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|
| + | Y | Y | N/A | N/A | N |

### Utilities

The C-17 had no observable impact on utilities at CAFB. This was predicted by the environmental assessment, because no major change in the facility capacity was expected. The following data reflects energy used by Charleston AFB for the period Oct 1990-May Sep 1994 (Beneway, 1995).

**TABLE 17: Monthly Energy Use (MBTU), Charleston AFB, South Carolina**

| | FY91 | FY92 | FY93 | FY94 |
|---|---|---|---|---|
| **Oct** | 25.960 | 15.361 | 23.688 | 25.613 |
| **Nov** | 36.580 | 48.150 | 35.236 | 34.445 |
| **Dec** | 46.610 | 49.923 | 50.337 | 50.637 |
| **Jan** | 54.280 | 57.603 | 49.153 | 56.525 |
| **Feb** | 43.660 | 49.036 | 48.857 | 45.043 |
| **Mar** | 43.070 | 36.039 | 49.745 | 38.272 |
| **Apr** | 19.175 | 18.906 | 29.610 | 15.309 |
| **May** | 19.175 | 15.952 | 15.397 | 16.486 |
| **Jun** | 19.765 | 18.610 | 18.062 | 17.958 |
| **Jul** | 20.355 | 20.973 | 21.023 | 21.197 |
| **Aug** | 20.650 | 18.315 | 18.950 | 18.842 |
| **Sep** | 15.340 | 11.816 | 11.844 | 12.954 |

One-way analysis of variance was used to determine if the differences in mean energy use per month were statistically significant. The analysis showed no significant difference between mean monthly energy use for the period FY91-FY94. Although the CAFB environmental assessment predicted an extremely small increase in energy usage due to larger buildings, energy usage actually decreased in FY94. This appears to be due to warm weather in March and April. Table 18 summarizes the impacts on CAFB utilities.

**Table 18: Summary of Utilities Impacts**

| Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|
| 0 | Y | N/A | N/A | N/A | N |

### Construction

The C-17 had a negative impact because of construction at CAFB. This was due in large part to the fact that more construction was required than originally planned. Initially, planners hoped to use existing C-141 hangars for the C-17. This was based on the assumption that the C-17 wingspan was slightly shorter than the C-141. In fact, the winglets added 10 feet to the width of the aircraft, requiring hangar modifications. Additionally, since the beddown location was officially classified, several early facility decisions were made without local coordination (May, 1995). As a result, the winglet discrepancy was not discovered until late in the beddown timetable, when several facilities were required to be constructed. This change in plans required additional permits and funding typical for large military construction projects.

**Table 19: Summary of Construction Impacts**

| Impact (+,-,0) | Prediction Accurate (Y/N) | Local Issue (Y/N) | Timing Issue (Y/N) | Funding Issue (Y/N) | Considered by SPO (Y/N) |
|---|---|---|---|---|---|
| - | N | N | Y | Y | N |

### Unresolved Issues

The beddown EA noted that there were limiting factors in the analysis. "The initial flight of the C-17 has been scheduled for December 1990: The lack of an existing aircraft and the amount of remaining time before the initial beddown will further complicate this analysis" (Department of the Air Force, 1989: 56). One area that the EA could not address was the airspace near Charleston AFB that the C-17 would use for low level training. The Military Airlift Command planned to address airspace issues in a separate analysis.

Other unresolved issues impacted the Charleston AFB community. The acquisition process was lengthened by substantial Congressional oversight. This affected beddown timetables and added uncertainty to the planning process. The question about the number of C-17s that Congress would authorize magnified the uncertainty. Finally, Charleston AFB was responsible for many facets of the Congressionally mandated Reliability, Maintainability and Availability Evaluation (RM&AE). This evaluation required off-site operations at several locations, including Barstow-Dagget Airfield in Southern California, where a fuel spill made authorities aware that no environmental planning existed for deployed locations. The ramifications of this discovery are discussed in the conclusion chapter of this thesis.

## Framework for Environmental Planning in Acquisition

The third research question asks:

| 3. How were CAFB environmental issues addressed during the C-17 acquisition process? |
|---|

Appendix C contains a flow chart which summarizes current environmental planning guidance available to weapon system program managers. Although the C-17 was developed before this guidance was created, the flow chart provides a model for comparing current and historic practice.

The first issue to address in answering research question number three is determining who was responsible for environmental planning. Next, it is critical to know when the planning was done and what kind of guidance existed at the time. Finally, it is instructive to review *how* the analysis was completed and *why* it failed to address some key issues. As Yin suggests, a case study such as this one is "appropriate when a 'how' or 'why' question is being posed" (Yin, 1989: 20). Here the case study focused on events at Wright Patterson AFB that preceded the decision to base the C-17 at Charleston AFB.

### Who Performed C-17 Environmental Planning?

The earliest C-17 environmental planning documents were prepared in 1981. At that time, the aircraft was in the exploration and definition phase, and was known as the C-X. Environmental planning for a new weapon system such as the C-X was accomplished by Aeronautical Systems Division (ASD) staff. The ASD environmental staff consisted of two people. They faced the challenge of compliance with little guidance or support. "It

was not unusual in 1981 to find small environmental staffs. More emphasis is placed on environmental issues now. Today there are more like 35 people working here" (Lawrence, 1995). The small staff reflected the fact that environmental planning was not a high priority in acquisition at the time.

According to a DoD Inspector General Audit Report, prior to 1993, environmental planning was a low priority in all the military department Major Defense Acquisition Programs (MDAPs). The Inspector General found that DoD priorities were focused on installation compliance and cleanup, rather than acquisition.

> Military Departments did not establish a means for the environmental engineers and the acquisition community to exchange information on environmental consequences of MDAPs. Overall, this orientation of environmental planning towards facilities and installations occurred because DoD and the Military Departments have not established environmental planning as a priority for MDAPs. (Department of Defense, 1993: 25)

Knowledge of who prepared early environmental documentation provides insight into the analysis. Clearly, lack of guidance and staffing influenced the quality of environmental planning. This lack of guidance became very clear when ASD attempted to supplement the C-X environmental assessment in 1989-1990. The ASD environmental planners updated the EA to include updated information for the C-17. They submitted several drafts to Air Force Systems Command (AFSC) for approval. In November 1990, the legal staff at AFSC declared that there was no CEQ or NEPA regulation that required EAs to be supplemented. They explained:

> The data contained in the updated EA does not appear to be "significant" from a NEPA standpoint, as it still leads to a finding of no significant impact. Based on these considerations, there does not seem to be any regulatory requirement to prepare a supplemental EA at this juncture. (Headquarters Air Force Systems Command, 1990)

A supplemental EA with C-17 data never replaced the C-X EA. No further programmatic environmental assessments were prepared for the C-17. This was unfortunate for the planners at Headquarters Military Airlift Command (HQ MAC), who needed baseline C-17 information to prepare the Charleston AFB beddown EA.

In the case of the CAFB beddown EA, the staff at HQ MAC originally planned to abbreviate the NEPA process by using a Categorical Exclusion, the lowest level of environmental analysis (Calliot, 1995). The idea was that because each C-17 would replace one C-141, no in-depth environmental planning was required. However, Headquarters Air Force required HQ MAC to prepare an EA. In 1989, when the CAFB beddown EA was prepared, HQ MAC staff faced manpower challenges similar to those at ASD. These factors influenced the quality of the beddown EA. Another complicating factor is that the beddown EA was accomplished in a very short period because of the decision to require more analysis than just a Categorical Exclusion. In many respects, HQ MAC staff produced a high quality document considering the time, manpower and budget constraints they faced.

**When Was Environmental Planning Accomplished for the C-17?**

Environmental planning guidance was sparse in the acquisition community in 1981. In fact, the Air Force did not publish its Environmental Impact Analysis Process (EIAP) regulation until August 1982 -- twelve years after the passage of the NEPA. With limited guidance and resources, the Aeronautical Systems Division staff produced an

environmental assessment for the C-X aircraft, anticipating that DoD would acquire a new cargo aircraft. The planners knew the C-X EA was generic and incomplete, but they at least had a framework for future planning documents. Their hope was that other planners could use the baseline information to improve upon the initial work.

It appears that the C-X EA was the only NEPA document released by ASD that addressed C-17 planning issues. The efforts to update the assessment in the late 1980s consumed a large amount of ASD staff time, but never resulted in an official document. As a result, when HQ MAC staff attempted to produce an expedited beddown EA in 1989, they spent time and resources gathering information that should have been already available. Had the quality of early EA documents been better, they would have presented an excellent opportunity for "tiering". The Code of Federal Regulations (CFR) defines tiering:

> Tiering refers to the coverage of general matters in broader environmental impact statements with subsequent narrower statements or environmental analyses, incorporating by reference the general discussions and concentrating solely on the issues specific to the statement subsequently prepared. (Code of Federal Regulations, 1995)

Because of the lack of data in the C-X environmental assessment, tiering was not a viable option for HQ MAC in 1989.

In 1991, ASD initiated the C-17 Environmental Working Group (EWG). The EWG began as a subcommittee of the Logistic Support Analysis Record (LSAR) Data Review Group. This group was formed to validate technical procedures and processes concerning the C-17. Monthly EWG meetings were hosted by McDonnell Douglas at their headquarters in Long Beach California. Representatives included personnel from

McDonnell Douglas, the SPO and CAFB personnel. Issues such as pollution prevention and Ozone Depleting Chemicals (ODC) elimination were discussed at these meetings. The key issues were how to eliminate ODCs without impacting the reliability, maintainability and availability of the aircraft.

In 1991, the C-17 System Safety Office assigned was assigned as new office of primary responsibility for environmental issues. The Director of System Safety, a field grade officer, assumed responsibility for the increasingly complex environmental arena. Finally in 1993, ASC assigned an officer to solely manage environmental issues.

**How Was Environmental Documentation Prepared?**

In 1981, when ASD environmental staff began documenting their analysis, the only information they had available was noise engine emission data for a range of possible aircraft. Using the NEPA, and CEQ regulations, they produced a generic ten page programmatic EA. This EA contained key ingredients required by law, including a Description of the Proposed Action and Alternatives. The table of contents from that document is shown in Table 20. It is instructive to analyze these contents in order to develop perspective for the acquisition environmental planning that followed.

In 1989, when HQ MAC prepared the beddown analysis for Charleston AFB, much more guidance was available. AFR 19-2 contained specific Air Force guidance, including a list of Categorical Exclusions to abbreviate the environmental planning for routine actions. But at least one person at HQ Air Force believed that the C-17 beddown at Charleston required an EA. HQ MAC had to change plans to apply CATEX 2Y:

"Proposed actions that are of such environmentally insignificant nature they clearly do not meet the threshold for requiring an environmental assessment or EIS" (Department of the Air Force, 1982: 65). As a result, due to limited time and resources, the beddown EA was published with the limitations described in the following section.

**Table 20: Contents of May 1981 Environmental Assessment for C-X Aircraft**

**Evaluation of Environmental Documentation**

The unclassified portion of the CAFB beddown EA contains sufficient information to evaluate environmental planning for the first C-17 operational base. With few exceptions, the document met criteria for environmental assessment documentation. Some improvement areas were noted, and these are described below. Table 21 presents a summary of the evaluation.

**Table 21: Environmental Document Evaluation**

| CRITERIA | SCORE (Y/M/N) |
|---|---|
| Comprehensiveness | Y |
| Specificity | Y |
| Isolate project impact | Y |
| Timing and duration | M |
| Data sources known | Y |
| Explicit indicators | N |
| Magnitude provided | M |
| Objective measurement | Y |
| Significance scaled | Y |
| Criteria explicit | M |
| Uncertainties made known | N |
| Risks identified | Y |
| Alternatives compared | N |
| Impacts aggregated | Y |
| Public involvement seen | N/A |
| Affected groups visible | Y |
| Setting described | Y |
| Format for summary | N |
| Key issues highlighted | N |
| Match NEPA regulations | Y |

Y = Yes (Meets Criteria)
M = Marginal (Partially meets criteria)
N = No (Does not meet criteria or minimally meets criteria).

**Comprehensiveness**

The document meets the comprehensiveness criteria. A range of impacts was addressed by the beddown EA. The existing environment was analyzed for pollution impacts, ecological impacts and socioeconomic and cultural impacts. One weakness of the document is that discussion is abbreviated. For example, seven of the eleven environmental categories were covered in two pages of the document. The document was written as if the beddown decision was already made. For example, in the section entitled 'Alternatives to Proposed Action', the EA noted that "Charleston is the candidate to receive the first operational squadron because it was most cost effective and efficient and satisfies other requirements identified previously" (Department of the Air Force, 1989:6). Further, no discussion of cumulative effects was found in the document. A cynical observer might wonder why the EA was even written. Overall, however, the document meets the criteria by considering a wide range of possible impacts to the affected environment.

**Specificity**

The document meets the specificity criteria. The EA presented a systematic approach to the analysis, but in some cases lacked detailed discussion of the parameters to be examined. In the Air Quality arena, the document was very specific regarding units of measure and significance of impact. Yet in other areas such as solid waste, very little information was presented to quantify possible impacts. In many cases it appears as if initial assumptions were made regarding number of aircraft, and impacts were

perfunctorily reported based on these numbers. For example, the EA estimated that 533 personnel would be withdrawn from the base. Several figures such as gallons of water and pounds of solid waste disposal were reported without putting the numbers in context.

**Isolate project impact**

The beddown document meets the project isolation criteria. The assessment for this beddown was successful in focusing on the impacts of this action independent of other actions. A reader can easily determine the impact of C-17 beddown, apart from other environmental changes produced by other causes.

**Timing and duration**

The document marginally meets the timing and duration criteria. Short term impacts, such as construction debris and runoff, were discussed as well as the longer term concerns such as landfill life and water treatment volume. However, long term effects were not discussed in areas such as air quality and socioeconomics.

**Data sources known**

The document meets the data source criteria. In several instances throughout the document, sources were referenced to allow reviewers to follow up on data questions. The final two pages of the EA presented a list of references and personnel contacted.

**Explicit indicators**

The document does not meet the explicit indicators criteria. Specific measurable indicators for quantifying impacts are not identified or used. The EA focused on air quality standards and noise contours, but did not describe any parts of the affected environment that can be used as indicators.

**Magnitude provided**

The document marginally meets the magnitude criteria. It presented measurable, easy to understand predictions of impacts. However, it did not provide language to put the magnitude of impacts in perspective.

**Objective measurement**

The document meets the objectiveness criteria. It cited experts from the South Carolina Department of Health and Environmental Control. It used objective guidance from the Air Installation Compatible Use Zone (AICUZ) report to identify noise concerns in the Charleston AFB area. Data cited in the EA can be measured objectively (e.g. gallons of water used, percent population increase).

**Significance scaled**

The document meets the significance scaling criteria. It assessed the impact with regard to its importance in the local and regional scale. This is especially true in the socioeconomic discussion, where regional economy was discussed at length.

**Criteria explicit**

The document marginally meets the explicitness criteria. For air quality and noise analysis, the EA was very explicit regarding criteria. For the remaining categories, however, information was presented without explanation regarding standards or the meaning of the numeric information.

**Uncertainties made known**

The document does not meet the uncertainty identification criteria. It was written as if the decision to purchase and deploy 210 C-17 aircraft was already made. This was a faulty assumption, as evidenced by the acquisition history of the C-17. Uncertainty regarding the number of C-17s in the USAF inventory affects planning for the number of aircraft at Charleston AFB. Therefore, some discussion regarding the degree of certainty of the impact significance should have been included in the document.

**Risks identified**

The document meets the risk identification criteria. No high loss potential risks were identified during the analysis.

**Alternatives compared**

The document does not meet the alternative comparison criteria. Although three alternatives were presented, two were immediately discounted and not discussed any further in the EA. The EA was written as if the decision was already made.

**Impacts aggregated**

The document meets the impact aggregation criteria. It discussed all reasonable impacts that will occur if the beddown decision was made. It also considered scenarios where the beddown occurred, without a portion of the associated construction projects.

**Public involvement seen**

The public involvement criteria was not assessed since the environmental assessment was classified.

**Affected groups visible**

The document meets the visibility criteria. It discusses environmental impacts in terms of the effect on the surrounding community. Population is estimated immediately and concern for civilian agricultural activities is cited.

**Setting described**

The document meets the setting description criteria. Section two, 'Existing Environment' presents an overall perspective of the Charleston AFB environment. Several key features about the surrounding area are described in detail. Key features such as the high water table and airfield elevation are highlighted early in the document. Local environmental standards are described and environmental authorities are identified to provide an objective contact point for interested personnel. For example, ambient air quality standards for the state are compared with national standards.

### Format for summary

The document does not meet the summary criteria. No summary tables are presented. The document lacks an overview section to summarize the analysis approach and results. This issue is discussed further in the conclusion chapter of this thesis.

### Key issues highlighted

The document does not meet criteria for highlighting key issues. There was no executive summary, or attempt to differentiate key C-17 environmental planning issues from other discussion.

### Match NEPA regulations

The document meets the NEPA regulation criteria. At the time the beddown EA was published, Air Force guidance consisted of Air Force Regulation 19-2, which was written to assist Air Force agencies comply with the National Environmental Policy Act. The document appears to follow AFR 19-2 guidance closely.

## Lessons Learned

The fourth research question asks:

| |
|---|
| 4. What lessons learned from the C-17 beddown at CAFB can be applied to other weapon system beddowns? |

Evidence analyzed in this chapter will be discussed in the conclusion chapter. The answer to this question is derived from the information used to answer questions 1-3.

## Summary

The evidence collected in this case study was analyzed to determine the effectiveness of environmental planning in the acquisition of the C-17 Globemaster III. In two of the eleven categories addressed in the CAFB Beddown EA, minor negative impacts were observed. Negative impacts were not caused by unique local conditions. However, in three categories, positive impacts occurred. The EA accurately predicted impacts in nine of the eleven categories.

A framework of environmental planning in acquisition was constructed to compare C-17 environmental history with current planning policy. C-17 environmental planning activities were described to show how they were accomplished and why they failed to address some key areas.

Finally, the CAFB Beddown Environmental Assessment was evaluated using criteria to determine the effectiveness of impact identification, measurement, interpretation, and communication. The EA failed to meet five of the twenty criteria evaluated. The results of this analysis are discussed in the following chapter.

# V. Conclusions and Recommendations

## Chapter Overview

This chapter summarizes the problem statement, methodology and results of this research. It presents conclusions from a case study of environmental issues related to the C-17 Globemaster at Charleston AFB. The discussion includes events from 1980, when C-17 development began, through 1995, when the first full squadron of C-17s was in place at CAFB. It focuses on the relationship between the environmental and acquisition history of the C-17. Conclusions describe the role of environmental planning in weapon system acquisition. Finally, the researcher recommends areas for further study.

## Research Design

This research was designed to increase corporate understanding of the role of environmental planning in acquisition. Particular attention was focused on the period June 1993 - June 1995, when the first squadron of C-17s was gradually bedded down at Charleston AFB. Specifically, the research was designed to answer the four investigative questions listed previously, and repeated below:

1. What environmental problems occurred during the beddown of the C-17?

2. Which, if any, CAFB environmental problems resulted from unique local environmental requirements or conditions?

3. How were CAFB environmental issues addressed during the C-17 acquisition process?

4. What lessons learned from the C-17 beddown at CAFB can be applied to other weapon system beddowns?

The research questions guided the literature review, methodology and analysis presented in previous chapters. Conclusions were organized in order to answer the research questions in order. Each question will be addressed in turn in this chapter.

## Conclusions

### 1. What environmental problems occurred during the beddown of the C-17?

Document reviews, personal interviews and site observations confirmed that three minor problems occurred during the beddown of the C-17. Two of the problems occurred on base during the beddown, and one occurred at a remote location where CAFB aircraft were flying aircraft evaluation missions. Although the latter of these problems did not occur at Charleston AFB, it is noteworthy because it impacted CAFB personnel.

The most serious problem that occurred during the beddown of the C-17 involved hazardous material management in a McDonnell Douglas maintenance hangar. The concept of operations in that hangar was to perform maintenance that Air Force C-17 personnel were not yet trained to do. This involved many chemicals that were used in a hangar not equipped for hazardous material storage. Several root causes can be identified for this problem.

Since production of the C-17 was concurrent with testing, several changes in maintenance and material were made during the beddown. This resulted in excess material such as adhesives, which later was disposed as hazardous waste. Because a small McDonnell Douglas (MD) team was contracted to perform interim maintenance support

during beddown, there was a problem with hazardous material supply. This problem was compounded by the fact that MD was required to design the C-17 so that it used material already in the government inventory. As a result, MD often was forced to use maintenance material that was more hazardous than state-of-the-art. Further, MD had to buy materials from the government, then bill it as part of a contract modification. The result of this system was that the contractor stockpiled a large quantity of hazardous material that was no longer usable for the C-17, or any other application on CAFB.

Although the hazardous material problem was minor, and quickly solved by good management, several lessons can be derived from the experience. One of the problems was that the hangar that was given to McDonnell Douglas had no provisions for hazardous material storage. Additionally, the, hazardous material was not used or inspected routinely. Further, the supply system was not conducive to purchasing small amounts of hazardous material. The latter problem may be solved by the new hazardous material pharmacy on base. Finally, requiring a contractor to use material already in the government inventory reduced opportunities for waste minimization. Current pollution prevention initiatives in the C-17 program address that issue.

The second problem during the beddown occurred when construction plans were increased due to the wing span of the C-17. The secrecy surrounding early C-17 facility support planning prevented installation engineers from identifying the winglet problem early in the planning process. As a result, expedited construction permit applications were required, and only limited environmental analysis was considered for the expanded construction.

The final problem with the beddown of the C-17 occurred during the Congressionally required Reliability Maintainability and Availability Evaluation. The RM&AE required Charleston crews to fly into Barstow-Dagget Airfield in California. As part of that operation, ground support, including fuel storage was required. When a fuel spill occurred during early training for the RM&AE, Charleston AFB environmental staff were required to expedite environmental planning for the site, and obtain permits to operate from Southern California regulatory authorities. The lesson learned is that the RM&AE is an exercise where acquisition requirements meet with installation operations, and improved coordination and planning are required to avoid environmental impacts caused by the testing phase of weapon system acquisition.

**2. Which, if any, CAFB environmental problems resulted from unique local environmental requirements or conditions?**

There are several reasons why Charleston AFB was an excellent choice for the beddown of the C-17. The base is in an air quality attainment zone, close to the Atlantic Ocean. The base enjoys compatible development with the surrounding area. The regulatory climate is friendly and cooperative. None of the problems noted above resulted from unique local requirements or conditions.

**3. How were CAFB environmental issues addressed during the C-17 acquisition process?**

The acquisition of the C-17 occurred during a period where environmental regulations were rapidly changing. When acquisition of the C-X aircraft was being debated, the Air Force had not yet even released its Environmental Impact Analysis Process (EIAP) regulation. Environmental compliance and pollution prevention were low priorities when the first C-17 was fabricated. However, in the early 1990s, several key events occurred that improved the environmental friendliness of the C-17. One month before the first test flight of the Globemaster III, the C-17 Environmental Working Group met in Long Beach California to "facilitate technical interchange between the developers, users and supporters of the C-17" (Aeronautical Systems Center, 1991).

Unfortunately, prior to 1991, the environmental history of the C-17 was similar to its acquisition history. Several environmental initiatives were begun but not finished. Most notably, the programmatic C-X environmental assessment remains the only C-17 NEPA environmental planning document completed by ASC. Even though one of the EWG objectives was to "ensure completion of the proper environmental documentation including an environmental assessment for the C-17 production program" (Aeronautical Systems Center, 1991), there is no evidence that this ever occurred.

Aeronautical Systems Division personnel became more proactive as the C-17 program matured. In March 1992, the program director for the C-17 released a letter outlining pollution prevention goals. Directors of logistics, engineering and system safety were all

tasked to keep the commanding general informed on pollution prevention progress. New chemicals were considered to replace the worst hazardous materials, provided they did not harm the aircraft. Simultaneously, Air Force leaders were reviewing technical orders to determine what uses of hazardous materials could be reduced or eliminated. Pollution prevention opportunities were sought out, and continue to be explored as Charleston AFB personnel become more familiar with C-17 maintenance tasks.

None of the NEPA documentation for the C-17 addresses pollution prevention issues. In fact, neither the C-X environmental assessment, nor the Charleston AFB beddown environmental assessment even address hazardous materials. This is in part because very little information was available in 1981 when the C-X EA was written. Further, the original plan was to apply a Categorical Exclusion to the beddown EA, so detailed analysis was only performed on the areas where data was readily available, such as noise and air emissions (Calliot, 1995).

Today, a new approach to environmental planning is being introduced by ASC. It consolidates all environmental issues into one Programmatic Environmental Assessment (PEA) document, of which NEPA planning is a part. The idea of the PEA is to evaluate the impacts of a weapon system on the environment, while considering the effects of environmental requirements on the weapon system over its life cycle (Nelson, 1995). The concept here is to track all acquisition environmental information in one place, where it is easily accessible for use in decision making. The PEA format is currently being revised by ASC so that a standardized format can be used by all weapon system program managers. An executive summary of the PEA is reviewed by the Defense Acquisition Board prior to

major program milestone decisions. This, above all, reflects the importance of environmental issues in the acquisition process.

**4. What lessons learned from the C-17 beddown at CAFB can be applied to other weapon system beddowns?**

One lesson learned from the C-17 beddown is that good communication between the aircraft provider (AFMC) and the weapon system user (e.g. AMC) enhances environmental quality. Although the relationship between the operational world and the acquisition world is difficult to describe due to the vast differences in language and daily requirements, it must be considered. A weakness in the DoD environmental climate was identified when the Inspector General noted that environmental attention was overly focused on installation cleanup and compliance, neglecting the acquisition world. Improved communications between aircraft operators, maintainers, and acquisition personnel will increase the efficiency of pollution prevention efforts, because the user can best identify problems, while the acquisition personnel can often provide the fix.

Another lesson learned from the C-17 is how to perform environmental assessments. Several improvement areas have been identified in this area. Much of the problem with C-17 environmental planning stems from the fact that the earliest efforts to comply with the NEPA predate good guidance. Before the C-17 was accepted by Congress, ASD's idea was to accomplish an assessment of the concept aircraft. This document was intended to be used as a baseline for future assessments, including beddown documents.

Unfortunately, because there was so much uncertainty related to the C-17 program, only a very generic environmental planning document was possible. At the time of the C-X draft, ASD environmental planners did not know who the aircraft contractor would be, or who would manufacture the engines. The good news was that there were specifications regarding engine noise and emissions because the aircraft would be FAA approved. Another lesson learned here is that information can be found in several places other than Air Force databases.

In theory, a good programmatic environmental assessment serves as a basis for the beddown documentation. In the case of the C-17, this did not occur, and early environmental documentation was very weak. Fortunately the beddown location was well suited for a new aircraft with low emissions and quiet engines. The beddown effort was not hindered by poor environmental planning in this case, but there certainly was potential for anyone to question the quality of NEPA documentation. For future beddowns, high quality environmental planning is a must.

Another problem noted by the researcher was that the environmental assessment had no discussion about hazardous material or hazardous waste management. Considering the volume of hazardous materials that are required to support the C-17, one would expect some discussion about their impact. In fact, these issues were addressed in a totally separate forum. This forum was the C-17 Hazardous Materials Working Group, chartered in 1991 (Cook, 1991).

One of the challenges associated with performing an environmental postaudit is that the units of measure may not be consistent. For example, in the 1989 EA, analysts

discussed the "Charleston Region" as the main area for looking at socioeconomic impacts. Yet in the 1995 commander's summary (a document dedicated to discussion of economic impact of base development), Charleston County is the focus of socioeconomic discussion, and no mention is made of the "Charleston Region". The problem here is that the sizes of the geographic areas are tremendously different, making comparison difficult at best. A lesson learned is that in environmental analysis, planners should strive for consistent units of measure.

**Discussion of Results**

One problem with this type analysis is the fact that the environmental planning was done at a time when much of the information about the initial beddown location was classified. Much of the analysis that would be important at a base cannot be completely done when there is so much uncertainty about the location and number of planes to be stationed at the location. One approach to this problem is to explicitly address the uncertainty, and analyze for best case, expected case, and worse case.

The idea of performing an environmental postaudit is instructive within certain bounds. First of all, there are few occasions when predictions can be directly compared to reality, because there are so many confounding factors. For example, the water supply and waste water data is sensitive to temperature and precipitation. A comparison of data from year to year must include some consideration of storms. Further, the quality of the data must be considered. There are cases where wastewater numbers were exactly the same for several months. Quite possibly a meter was not operating properly. This leads an

investigator to question the accuracy of the readings. However, more important than whether the data is highly accurate is the trends that it suggests. By noting trends, insight can be gained, though in this case the data was more interesting for what it did not show (impacts) rather than for what it did show (no significant changes).

A fair question may be 'Was an EA even required?' or 'is study of the EA useful?'. The answer to both these questions is 'Yes', because the Air Force needs to know the environmental risks associated with aircraft beddown activities. Further, the Air Force needs to know if its environmental analyses are accurate inputs to the decision making process.

This research effort used tools to explore the NEPA planning process and determine if it was appropriately applied during the C-17 acquisition process. In the case of the C-17 at Charleston Air Force Base, early planning was weak and the environmental impacts were minimal. It would seem logical that poor environmental planning would result in a large number of impacts, but in this study that was not the case. One possible reason for these results is that although early planning was poorly documented, there was steady improvement as the acquisition proceeded. Further, independent USAF and McDonnell Douglas pollution prevention efforts were ongoing in the years prior to beddown. Finally, a capable and enthusiastic Charleston AFB environmental management team contributed to the beddown effort. All of these efforts helped mitigate C-17 environmental impacts.

## Areas For Future Research

The researcher identified several areas for follow-on research:

1. Perform a similar case study at another Air Force base.

2. Collect data regarding the quality of environmental analysis documents in the U.S. Air Force.

3. Research the history of environmental planning in acquisition and develop a methodology to incorporate environmental requirements in timely manner.

4. Prepare environmental references and documentation to incorporate into the Air Force Acquisition Model (AFAM).

5. Research the effectiveness of Air Force Programmatic Environmental Analyses.

6. Study the cost and effectiveness of pollution prevention activities.

## Summary

This thesis explored the role of environmental planning in the acquisition process. Conclusions were presented in this chapter. In the case of the beddown of the C-17 Globemaster III at Charleston AFB, few environmental impacts occurred. This does not appear to be because of outstanding planning, but rather because of agreeable local conditions and proactive environmental management just prior to the beddown of the aircraft. Several lessons were learned by the environmental planners and acquisition personnel associated with the C-17. Application of these lessons to future weapon system beddowns will improve the process and enable future planners to make better use of available environmental tools.

## Appendix A: Checklist for Document Review

Date
Subject
Source
Water Issues?
Air Issues?
Hazardous Waste Issues?
Cultural Management Issues?
Noise Issues?
Corroborating Evidence?
Cross Reference Number of related evidence

Index of documentation evidence

1989 Environmental Assessment for C-17 Beddown at Charleston AFB
CAFB Hazardous Waste Management plan
CAFB Spill Plan
C-17 Hazardous Material Working Group Minutes
McDonnell-Douglas Publication: "C-17 News"
Bioenvironmental Engineering Reports
Air Permit
Construction Permits
Logistic Group Correspondence
Water Usage Reports
Wastewater Production Reports
Air Emission Reports

## Appendix B : Interview Data

## Interview References


Beneway, Capt Sandie, Deputy Chief, Environmental Management Flight, CAFB.

Bishop, Mr Randy, CAFB Environmental Compliance Technician

Blair, MSgt Gregory, CAFB Fuels Flight Environmental Manager

Braun, MSgt Michael, CAFB C-17 Maintenence Squadron Environmental Program Manager

Brewer, SSgt Edgar, CAFB Hazardous Material Pharmacy Customer Service Representative

Calliot, Ms Patricia, Former Environmental Planner, Military Airlift Command.

Clemons, SMSgt Tom, CAFB Aircraft Maintenence Superintendent

Coffey, MSgt Clayton, CAFB Hazardous Material Pharmacy Superintendent

Cook, Mr Dale, CAFB Logistics Group Environmental Manager

Cummings, Lt Stacey, CAFB Environmental Officer

Dean, Mr Bill, CAFB Environmental Compliance Monitor

Deese, Mr Harold, CAFB Environmental Engineer

Easterby, Mr Glenn, CAFB Chief of Environmental Management Flight

Fanning, Mr Wayne, Assistant District Director, South Carolina Department of Health and Environmental Control

Frazier, Capt Daryl, Officer In Charge, CAFB C-17 Sortie Generation Flight

Fuqua, Ms Stacey, Risk Communicator, South Carolina Department of Health and Environmental Control

Hamilton, MSgt Jonny, CAFB C-17 Technical Order Manager

Lawrence, Mr David, Chief of Remediation, Headquarters Aeronautical Systems Center.

May, Mr Warren, CAFB Engineering Design Supervisor

McMillan, MSgt Roger, CAFB Aircraft Maintenence Environmental Superintendent

Nelson, Capt Mike, C-17 System Program Office Environmental Officer.

Pape, Mr Henry, CAFB Hazardous Waste Program Manager

Powell, Mr David, CAFB Air Program Manager

Rowe, Mr Todd, McDonnell Douglas Logistics Representative to CAFB

Smith, Capt Maria, CAFB Hazardous Material Pharmacy Flight Chief

Wilson, Capt Rob, CAFB C-17 Facility Program Manager

Youngblood, Mr Don, CAFB Community Planner

## C-17 Research Interview Worksheet

This interview contributes to a case study of the acquisition and beddown of the C-17 Globemaster III. Information about beddown experiences at Charleston AFB will be collected and analyzed as part of Capt Rich Houghton's graduate research at Air Force Institute of Technology. The research results will be reported in a thesis as part of the educational requirements for a master's degree. The key to this research is that the Air Force can learn some valuable lessons from the C-17 beddown. Information will be used to illustrate what actions we performed well, and what things we would do differently if we could.

Interviews will include seven standard questions and a flexible amount of follow up questions based on available time and level of experience of the interviewee. The following seven questions begin the interview:

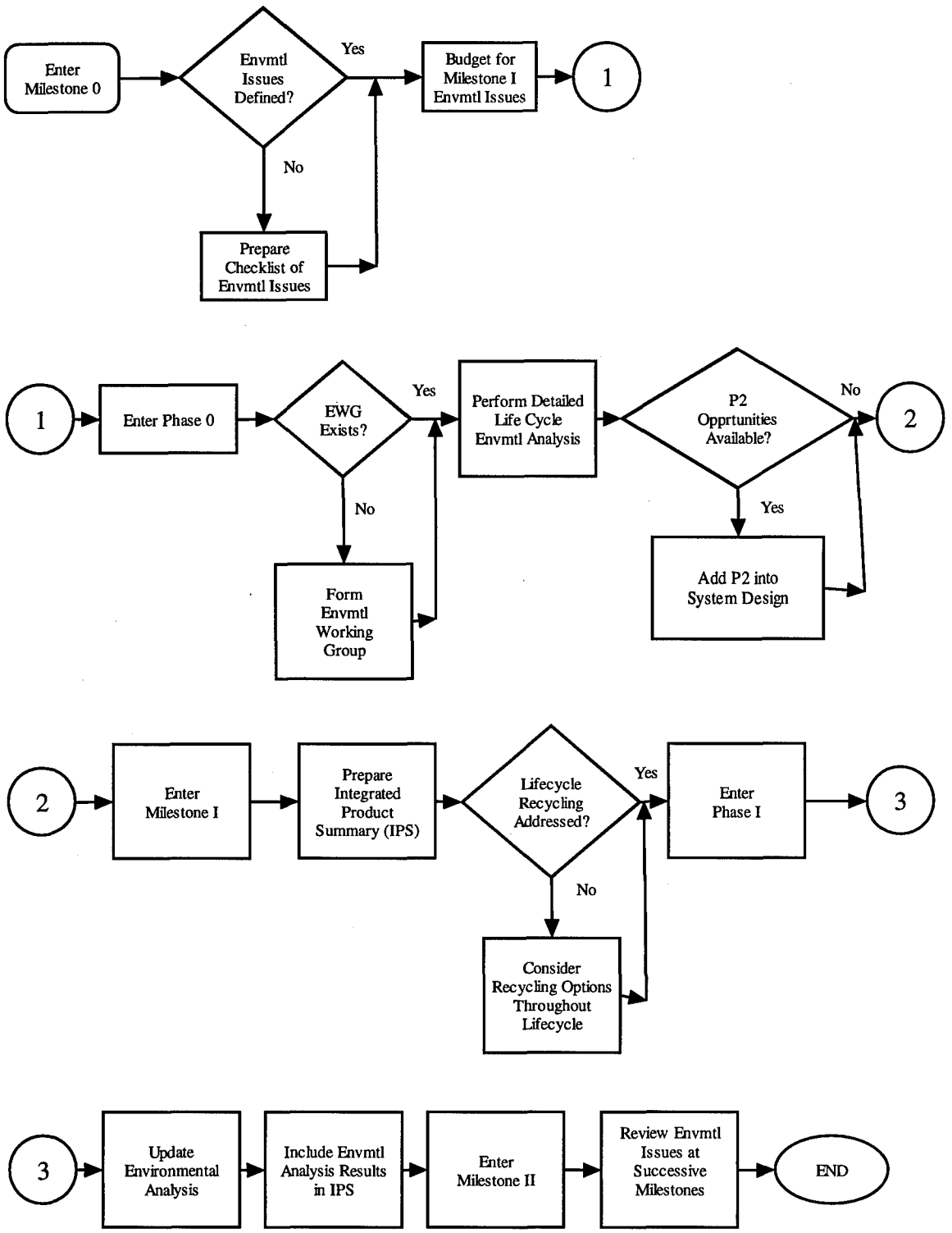
1. What is your duty title and AFSC?
2. How long have you been at Charleston AFB? (# Years and Months)
3. On a scale of 1-10, how would you characterize your knowledge of environmental laws and policies? (1 = low, 10 = high)
4. How would you rate the effect of the C-17 on your daily job? (1 = low, 10 = high)
5. To what extent have you needed information about the C-17 in order to perform your job? (1 = low, 10 = high)
6. When you needed information about the C-17, how timely was it? (1 = not , 10 = very)
7. Are there any people you recommend I interview to get further information?

Thank You.

## Charleston AFB Interview Data - June 1995

| NAME | # of MONTHS AT CAFB | SELF-ASSESSED ENVMTL SCORE | IMPACT OF C-17 ON JOB | NEED FOR C-17 INFO | TIMELINESS OF C-17 INFO |
|---|---|---|---|---|---|
| Capt Sandie Beneway | 8 | 8 | 9 | 8 | 7 |
| Mr Randy Bishop | 17 | 5 | 8 | 2 | 10 |
| Msgt Gregory Blair | 168 | 3 | 8 | 9 | 10 |
| Msgt Michael Braun | 19 | 5 | 9 | 1 | 10 |
| Ssgt Edgar Brewer | 144 | 6 | 3 | 4 | 8 |
| SMSgt Tom Clemons | 241 | 2 | 5 | 3 | 10 |
| Msgt Clayton Coffey | 47 | 7 | 3 | 5 | 8 |
| Mr Dale Cook | 170 | 3 | 9 | 10 | 7 |
| Lt Stacey Cummings | 18 | 6 | 2 | 2 | 10 |
| Mr Bill Dean | 84 | 8 | 7 | 5 | 8 |
| Mr Harold O. Deese | 16 | 6 | 2 | 2 | 9 |
| Mr Glenn Easterby | 64 | 10 | 8 | 8 | 8 |
| Mr Wayne Fanning | 240 | 10 | 2 | 4 | 10 |
| Capt Daryl Frazier | 84 | 4 | 9 | 9 | 10 |
| Ms Stacey Fuqua | 3 | 7 | 1 | 1 | 10 |
| Msgt Jonny Hamilton | 41 | 4 | 10 | 10 | 10 |
| Mr Warren May | 120 | 5 | 9 | 9 | 2 |
| Msgt Roger McMillan | 69 | 7 | 8 | 8 | 9 |
| Mr Henry Pape | 17 | 8 | 8 | 8 | 10 |
| Mr David Powell | 16 | 8 | 4 | 8 | 9 |
| Mr Todd Rowe | 42 | 6 | 10 | 10 | 10 |
| Capt Maria Smith | 5 | 6 | 3 | 8 | 8 |
| Capt Rob Wilson | 19 | 4 | 9 | 10 | 7 |
| Mr Don Youngblood | 103 | 6 | 8 | 8 | 4 |

# Appendix C: Flowchart of Acquisition Environmental Planning



## Appendix D: C-17 Timeline

| | |
|---|---|
| xx May 81 | Air Force Systems Command (AFSC) produces **Environmental Assessment (EA)** for C-X Aircraft |
| xx Aug 81 | USAF Chooses McDonnell Douglas (MD) C-17 to meet airlift needs |
| 23 Jul 82 | Limited low-level development Contract Award |
| 02 Nov 87 | Fabrication begins for first C-17 |
| 18 May 88 | First F-117 engine delivered |
| xx Dec 88 | Federal Aviation Administration Certifies F117-PW-100 engine |
| -- Jan 89 | Defense Acquisition Board (DAB) makes milestone IIIA low rate Initial Production Decision |
| 30 May 89 | C-17 System Planning Office completes **supplemental programmatic EA** to update the May 1981 C-X environmental planning documentation |
| 03 Aug 89 | **Environmental Assessment** and FONSI for CAFB beddown completed |
| 27 Nov 90 | AFSC legal experts **reject idea of supplemental programmatic EA** |
| 07 Mar 91 | C-17 System Safety Office assigned new **environmental issues** POC |
| 12 Aug 91 | C-17 Environmental and Hazardous Material Control Working Group at Douglas Aircraft corporation, Long Beach CA, chaired by C-17 SPO |
| 15 Sep 91 | First C-17 Flight, Edwards AFB CA |
| -- Nov 91 | First Maintenance Training Device at CAFB |
| 13 Feb 92 | C-17 **Environmental Working Group** meets at Long Beach CA |
| -Apr 92 | First C-17 Flight Simulator at CAFB |
| 07 May 92 | C-17 **Environmental Working Group** meets at Long Beach CA |
| 17 Aug 92 | CAFB Environmental Office outlines C-17 Environmental Concerns for 437 AW/CC |
| 14 Jun 93 | First C-17 arrives at CAFB, tail number 891192 (Sixth Production C-17) |
| 26 Aug 93 | Second C-17 arrives at CAFB (Seventh Production Aircraft) |
| xx Dec 93 | Fourth C-17 arrives at CAFB |
| 30 Mar 94 | DHEC issues **construction permit** for C-17 engine test facility |
| 18 May 94 | Seventh C-17 arrives at CAFB (Twelfth Production Aircraft) |
| 30 Jun 94 | Eighth C-17 arrives at CAFB |
| 07 Jul 94 | CAFB environmental office request investigation of C-17 fuel spills |
| 18 Nov 94 | Eleventh C-17 arrives at CAFB (Sixteenth Production Aircraft) |
| 18 Feb 95 | Thirteenth C-17 arrives at CAFB |
| 20 Jun 95 | Data Collection for Case Study at CAFB |
| 28 Jun 95 | CAFB Requests Permit Guidance for RM&AE from Mojave Desert Air Quality Management District |
| 29 Jun 95 | Mojave Desert Air Quality Management District grants approval to proceed with C-17 evaluation at Barstow-Dagget |
| 05 Jul 95 | USAF begins RM&AE at Barstow-Dagget Airfield |

# Appendix E: Statistical Analysis Results

## One-Way Analysis Of Variance for Water by Year

| SOURCE | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| BETWEEN | 3 | 4.114E+08 | 1.371E+08 | 2.84 | 0.0511 |
| WITHIN | 37 | 1.787E+09 | 4.830E+07 | | |
| TOTAL | 40 | 2.198E+09 | | | |

| | CHI-SQ | DF | P |
|---|---|---|---|
| BARTLETT'S TEST OF EQUAL VARIANCES | 2.82 | 3 | 0.4199 |

COCHRAN'S Q 0.3483
LARGEST VAR / SMALLEST VAR 2.5547

COMPONENT OF VARIANCE FOR BETWEEN GROUPS 8.926E+06
EFFECTIVE CELL SIZE 10.0

| YEAR | SAMPLE MEAN | GROUP SIZE | STD DEV |
|---|---|---|---|
| 92 | 2.092E+04 | 12 | 5005.8 |
| 93 | 2.756E+04 | 12 | 8000.9 |
| 94 | 2.746E+04 | 12 | 7823.4 |
| 95 | 2.914E+04 | 5 | 5788.8 |
| TOTAL | 2.578E+04 | 41 | 6949.8 |

TUKEY (HSD) PAIRWISE COMPARISONS OF MEANS OF WATER BY YEAR

| YEAR | MEAN | HOMOGENEOUS GROUPS |
|---|---|---|
| 95 | 2.914E+04 | I |
| 93 | 2.756E+04 | I |
| 94 | 2.746E+04 | I |
| 92 | 2.092E+04 | I |

THERE ARE NO SIGNIFICANT PAIRWISE DIFFERENCES AMONG THE MEANS.

CRITICAL Q VALUE 3.805 REJECTION LEVEL 0.050
STANDARD ERRORS AND CRITICAL VALUES OF DIFFERENCES
VARY BETWEEN COMPARISONS BECAUSE OF UNEQUAL SAMPLE SIZES.

## One-Way Analysis Of Variance for Sewage by Year

| SOURCE | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| BETWEEN | 3 | 8.529E+08 | 2.843E+08 | 4.27 | 0.0110 |
| WITHIN | 37 | 2.464E+09 | 6.658E+07 | | |
| TOTAL | 40 | 3.317E+09 | | | |

| | CHI-SQ | DF | P |
|---|---|---|---|
| BARTLETT'S TEST OF EQUAL VARIANCES | 0.45 | 3 | 0.9304 |

COCHRAN'S Q 0.3156
LARGEST VAR / SMALLEST VAR 1.5012

COMPONENT OF VARIANCE FOR BETWEEN GROUPS 2.188E+07
EFFECTIVE CELL SIZE 10.0

| YEAR | SAMPLE MEAN | GROUP SIZE | STD DEV |
|---|---|---|---|
| 92 | 3.653E+04 | 12 | 9032.6 |
| 93 | 2.502E+04 | 12 | 7493.9 |
| 94 | 2.976E+04 | 12 | 8151.9 |
| 95 | 3.381E+04 | 5 | 7372.0 |
| TOT | 3.085E+04 | 41 | 8159.9 |

TUKEY (HSD) PAIRWISE COMPARISONS OF MEANS OF SEWAGE BY YEAR

| YEAR | MEAN | HOMOGENEOUS GROUPS |
|---|---|---|
| 92 | 3.653E+04 | I |
| 95 | 3.381E+04 | I I |
| 94 | 2.976E+04 | I I |
| 93 | 2.502E+04 | .. I |

THERE ARE 2 GROUPS IN WHICH THE MEANS ARE
NOT SIGNIFICANTLY DIFFERENT FROM ONE ANOTHER.

CRITICAL Q VALUE 3.805 REJECTION LEVEL 0.050
STANDARD ERRORS AND CRITICAL VALUES OF DIFFERENCES
VARY BETWEEN COMPARISONS BECAUSE OF UNEQUAL SAMPLE SIZES.

## One-WayAnalysis Of Variance for Energy Usage by Year

| SOURCE | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| BETWEEN | 3 | 15.0945 | 5.03150 | 0.02 | 0.9955 |
| WITHIN | 44 | 10080.3 | 229.099 | | |
| TOTAL | 47 | 10095.4 | | | |

| | CHI-SQ | DF | P |
|---|---|---|---|
| BARTLETT'S TEST OF EQUAL VARIANCES | 0.49 | 3 | 0.9204 |

COCHRAN'S Q 0.3076
LARGEST VAR / SMALLEST VAR 1.5385

COMPONENT OF VARIANCE FOR BETWEEN GROUPS -18.6723
EFFECTIVE CELL SIZE 12.0

| FY | SAMPLE MEAN | GROUP SIZE | STD DEV |
|---|---|---|---|
| 91 | 30.385 | 12 | 13.535 |
| 92 | 30.057 | 12 | 16.788 |
| 93 | 30.992 | 12 | 14.983 |
| 94 | 29.440 | 12 | 15.062 |
| TOTAL | 30.218 | 48 | 15.136 |

TUKEY (HSD) PAIRWISE COMPARISONS OF MEANS OF TMBTU BY FY

| FY | MEAN | HOMOGENEOUS GROUPS |
|---|---|---|
| 93 | 30.992 | I |
| 91 | 30.385 | I |
| 92 | 30.057 | I |
| 94 | 29.440 | I |

**THERE ARE NO SIGNIFICANT PAIRWISE DIFFERENCES AMONG THE MEANS.**

CRITICAL Q VALUE 3.776 REJECTION LEVEL 0.050
CRITICAL VALUE FOR COMPARISON 16.501
STANDARD ERROR FOR COMPARISON 6.1793

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*Vita*

Captain Richard H. Houghton Jr. [redacted]

He graduated from Bergen Catholic High School and attended Stevens Institute of Technology, graduating with a Bachelor of Engineering Degree and a USAF commision in May, 1987. He served as a traffic engineer for the County of Los Angeles before entering active duty at the 60th Civil Engineering Squadron in January, 1988.

Captain Houghton was the Environmental Coordinator for Travis AFB from January 1988 through January 1992. He then became the Chief of Readiness for the 60th CES. From June - October 1992, Captain Houghton was assigned to the U.S. Army as Planning Officer, Deputy Chief of Staff, Engineer at Joint Task Force Bravo, Soto Cano Airbase, Honduras. From March - July 1993, he was assigned as Base Civil Engineer at Riyadh Air Base, Kingdom of Saudi Arabia.

After returning to Travis, he was chief of the 60 CES Airbase Operability Flight until attending Squadron Officer School in October 1993. From December 1993 - May 1994, Captain Houghton was the Chief of the 60 CES Operations Flight. He entered the Air Force Institute of Technology School of Engineering in May 1994. After graduation, he will serve as Chief of the Environmental Management Flight at Kunsan AB, Korea.

[redacted]